Thirtieth Illinois Custom Spray Operators Training School

Summaries of Presentations

January 4 & 5, 1978
Urbana, Illinois
and

1978 Agricultural Pesticide Dealers and Applicators Handbook

Cooperative Extension Service
University of Illinois
at Urbana-Champaign
College of Agriculture
in Cooperation with
the Illinois Natural History Survey

COOPERATIVE EXTENSION SERVICE
UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN

This training school is presented specifically for commercial applicators of agricultural chemicals by the University of Illinois at Urbana-Champaign, College of Agriculture, Cooperative Extension Service, and Illinois Natural History Survey, but is open to all persons involved in the handling of agricultural chemicals. The school promotes the proper, timely, and wise use of agricultural chemicals. We gratefully acknowledge the assistance of the Illinois Department of Agriculture, the U.S. Department of Agriculture, the Illinois Aerial Applicators Association, the Illinois Ground Sprayers Association, and the Illinois Fertilizer and Chemical Association in planning the program. Abstracts in this manual bring to you the latest research information, but do not constitute positive recommendation unless so stated. Statements made herein are the responsibility of either the speaker or the institution he represents. Reproduction and publication are permitted only with the approval of each author.

Many of the abstracts in this manual are research reports, and the chemicals listed are not registered for use by the public. Those listed in the official Circulars in the back of this booklet are officially registered for the suggested uses. Even in these instances, it is recognized that extreme variations in weather, cropping practices, fertilizer use, application techniques, use of other pesticides, and other factors may influence the effectiveness of the chemical. Adverse effects, such as poor results and plant damage, should always be reported to your county Extension adviser so that he may inform the interested people at the University of Illinois College of Agriculture and the Illinois Natural History Survey.

Many of the chemicals listed herein have common names which are used in preference to trade names. However, it is also possible that a chemical may only be known by its trade name. If there is more than one trademarked product for the same chemical, we ordinarily use the common chemical name, but occasionally through oversight an error may be made. If this has occurred, accept our apologies and call it to the attention of the author of the article.

The 30th Illinois Custom Spray Operators Training School

is dedicated to these loyal supporters, who
are attending their thirtieth sprayers school

Left to Right: Keith Walker, Good-Life Chemicals, Inc.; Robert Rider, Thompson-Hayward Chemical Company; Lillard Hedden, Hedden Agricultural Aviation; Fred Slife, University of Illinois; Weldon Wadleigh, Stauffer Chemical Company; H.B. Petty, University of Illinois.

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INSECTS

WEEDS

PLANT DISEASES

APPLICATION OF PESTICIDES

LEGISLATION

SAFETY

GENERAL AGRICULTURE

1979 Date for
31st Custom Spray School
JANUARY 9, 10, 11, 1979

THIRTIETH ILLINOIS
CUSTOM SPRAY OPERATORS TRAINING SCHOOL

January 4 and 5, 1978
Illini Union Building
University of Illinois at Urbana-Champaign

Sponsors: Cooperative Extension Service, University of Illinois at Urbana-Champaign College of Agriculture, Illinois Natural History Survey, Illinois Department of Agriculture, Illinois Aerial Applicators Association, Illinois Ground Sprayers Association, and Illinois Fertilizers and Chemical Association.

Registration:	January 3, Tuesday--8:30 a.m. - 4:30 p.m.	Convention Center
	7:30 p.m. - 9:30 p.m.	Ramada Inn
	January 4, Wednesday--8:00 a.m. - 5:00 p.m.	Illini Rooms, A,B,C
	January 5, Thursday--8:00 a.m. - 1:00 p.m.	Illini Union

SPECIAL EVENTS, TUESDAY, JANUARY 3

1. Illinois Ground Sprayers Association

RAMADA INN-Brundage, Zuppke, and Illiniwek Rooms
Wayne Tomlinson, President, Presiding

10:00 a.m. Laws and Regulations Governing Pesticide Use in Illinois. . . . . J.C. Hogancamp

10:30 Specialized Nozzles for Custom Spraying . . . . Industry Representatives

11:00 Marker Systems for Ground Sprayers. . . . . L.E. Bode

11:30 Lunch - Grange Room

1:30 p.m. Chemical Injury Troubleshooting for Custom Sprayers . . . . Panel and Open Discussion

3:00 Adjourn

2. Illinois Aerial Applicators Association

RAMADA INN-Alumni Room
Chuck Hendrickson, President, Presiding

10:00 a.m. Closed Systems for Aerial Spraying. . . . . R.W. Brazelton

10:30 Liability of Aerial Pesticide Applicators . . . . C.A. Bock

11:00 Laws and Regulations Governing Pesticide Use in Illinois. . . . . J.C. Hogancamp

11:30	Lunch - Grange Room	
1:30 p.m.	Chemical Toxicity and Its Effects.	D. Lacefield
3:00	Business Meeting	
4:00	Adjourn	

3. Special Smoker

RAMADA INN - Iowa, Indiana, Michigan, and Ohio Rooms

This special event is sponsored by the Illinois Fertilizer and Chemical Association.

If you are in town, say hello to old friends, meet new friends, and visit with the speakers between 8:00 and 9:30 p.m.

Ramada Inn—Guest Rooms are reserved for members of the press, Chuck Hardwick in charge, 7:30 to 9:30 p.m.

FORMAL PROGRAM

Illini Union Building, Illini Rooms

WEDNESDAY, JANUARY 4, 1978

FRED SLIFE, PRESIDING

8:45 a.m.	Unusual Pest Problems		
8:45	Insects	R. Randell	
9:00	Diseases.	M.C. Shurtleff	
9:15	Weeds	M.D. McGlamery	
9:30	Welcome	H.B. Petty	
9:40	Loyalty Awards.	O.G. Bentley	
10:00	Coffee		

PETE PETTY, PRESIDING

10:20	Update on Corn Diseases	M.C. Shurtleff	21
10:30	What's New in Weed Control.	M.D. McGlamery	26
10:45	How the Illinois Department of Agriculture Serves You.	Director J. Block	
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11:10	Symptoms of Misapplied Row Crop Herbicides.	V. Jennings	31
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11:40	Corn Nematodes: Chemical Control and Biology.	D. Norton	45
12:00	Incorporation of Herbicides in Reduced Tillage Systems	B.J. Butler, L.E. Bode	50
12:15 p.m.	Weed Control for Soybeans in 1978	L.M. Wax	52
12:30	Lunch		

WILLIAM GEORGE, PRESIDING

BOB RIDER, PRESIDING

THURSDAY, JANUARY 5, 1978
LILLARD HEDDEN, PRESIDING

WHO'S WHO

Behrens, R., Professor, Department of Agronomy, University of Minnesota, St. Paul, Minnesota

Bentley, O. G., Dean, College of Agriculture, University of Illinois

Black, K. D., Assistant Specialist in Entomology Extension and Survey Entomologist, University of Illinois, Illinois Natural History Survey, and U.S. Department of Agriculture

Block, J. R., Director, Illinois Department of Agriculture, Springfield, Illinois

Bock, C. A., Professor of Agricultural Law, Department of Agricultural Economics, University of Illinois

*Bode, L. E., Associate Professor Agricultural Engineering, University of Illinois

Brazelton, R. W., Extension Agricultural Engineer, University of California at Davis, Davis, California

Bremer, C. D., Assistant Entomologist in Pest Management in Extension, University of Illinois and Illinois Natural History Survey

**Brink, W. H., Extension Adviser in Agriculture, Montgomery County

**Burling, L. D., Executive Vice President, Illinois Fertilizer and Chemical Association, St. Anne, Illinois

**Butler, B. J., Professor of Agricultural Engineering, University of Illinois

**Gentry, D. A., Assistant Entomologist in Pesticide Training in Extension, University of Illinois and Illinois Natural History Survey

George, W. L., Professor and Head, Department of Horticulture, University of Illinois

**Hardwick, C. T., Communications Specialist in Extension, University of Illinois

Hedden, L., Hedden Agricultural Aviation, Pekin, Illinois

**Hendrickson, C., President, Illinois Aerial Applicators Association, Hendrickson Flying Service, Rochelle, Illinois

**Hiltibran, R. C., Associate Professor of Agronomy, University of Illinois and Biochemist, Illinois Natural History Survey

Hoeft, R. G., Associate Professor of Soil Fertility, Department of Agronomy, University of Illinois

**Hogancamp, J. C., Plant and Pesticide Specialist Supervisor and Pesticide Coordinator, Illinois Department of Agriculture, Springfield, Illinois

*Hopen, H. J., Professor of Vegetable Crops, Department of Horticulture, University of Illinois

*Jacobsen, B. J., Assistant Professor of Plant Pathology, University of Illinois

Jennings, V. M., Extension Botanist--Weed Science, Department of Botany and Plant Pathology, Iowa State University, Ames, Iowa

Jokela, J. J., Associate Professor of Forestry, University of Illinois

**Knake, E. L., Professor of Weed Science, Department of Agronomy, University of Illinois

**Kuhlman, D. E., Associate Professor of Agricultural Entomology and Extension Entomologist, University of Illinois and Illinois Natural History Survey

Lacefield, Delbert, Aeronautical Academy, AAC-140, Oklahoma City, Oklahoma

*McGlamery, M. D., Professor of Weed Science, Department of Agronomy, University of Illinois

McKibben, G. E., Professor of Crop Production, Department of Agronomy, University of Illinois
*Meador, D. B., Associate Professor of Pomology, Department of Horticulture, University of Illinois
**Moore, S. III, Professor of Agricultural Entomology, Extension Entomologist, University of Illinois and Illinois Natural History Survey, and Chairman of Sprayers' School Committee
Norton, D., Professor of Plant Pathology, Department of Botany and Plant Pathology, Iowa State University, Ames, Iowa
Ogden, R., U.S. Fish and Wildlife Service, Springfield, Illinois
Petty, H. B., Assistant Director of Cooperative Extension Service and Professor of Agricultural Entomology, University of Illinois
*Rachesky, S. R., Area Adviser, Pesticides, Chicago, Illinois, University of Illinois
*Randell, R., Associate Professor of Agricultural Entomology and Extension Entomologist, University of Illinois and Illinois Natural History Survey
Rider, R. F., Thompson-Hayward Chemical Company, Davenport, Iowa
*Sanderson, G. C., Head, Section of Wildlife Research, Illinois Natural History Survey and Professor, Ecology, Ethology, and Evolution
Scott, D. H., Associate Professor, Department of Plant Pathology, Purdue University, West Lafayette, Indiana
**Scott, W. O., Professor of Crop Production, Department of Agronomy, University of Illinois
Sechriest, R. E., Associate Entomologist and Assistant Professor of Agricultural Entomology, University of Illinois and Illinois Natural History Survey
Shaw, J., Junior Professional Scientist, Illinois Natural History Survey
**Shurtleff, M. C., Professor of Plant Pathology, Department of Plant Pathology, University of Illinois
**Slife, F. W., Professor of Crop Production, Department of Agronomy, University of Illinois
Thorne, M. D., Professor of Agronomy, Department of Agronomy, University of Illinois
**Tomlinson, W., President, Illinois Ground Sprayers Association, Tomlinson Fertilizers, Rushville, Illinois
*Turgeon, A. J., Associate Professor of Turf, Department of Horticulture, University of Illinois
Turpin, F. T., Assistant Professor, Department of Entomology, Purdue University, West Lafayette, Indiana
Wadleigh, Weldon, Stauffer Chemical Company, Omaha, Nebraska
Walker, W. Keith, Good-life Chemicals, Inc., Effingham, Illinois
Wax, L. M., Professor of Agronomy, Department of Agronomy, University of Illinois and U.S. Department of Agriculture
*Wedberg, J. L., Assistant Professor of Agricultural Entomology and Extension Entomologist, University of Illinois and Illinois Natural History Survey
*Williams, D. J., Assistant Professor, Department of Horticulture, University of Illinois

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*Extension Agricultural Pesticide Planning Committee member.
**Custom Spray Operators Training School Committee member.

1978 AGRICULTURAL PESTICIDE DEALERS AND APPLICATORS CLINICS

Sponsored by the College of Agriculture, University of Illinois, Illinois Natural History Survey, and the Illinois Department of Agriculture, Bureau of Plant and Apiary Protection

As a pesticide dealer or applicator, you are invited to attend one of the area agricultural chemical clinics. Researchers and Extension Specialists from the University of Illinois will discuss new application equipment and techniques, as well as new research and current suggestions for controlling weeds, insects, and diseases affecting crops.

Current Illinois law requires a person who applies a pesticide for hire outside a structure to be licensed by the Illinois Department of Agriculture. The categories for commercial and public pesticide applicators and operators are listed below. Individuals taking exams in categories 1 through 5 should attend the Agricultural Clinics.

1. Field Crop Pest Control Applicator or Operator
2. Demonstration and Research Pest Control Applicator
3. Regulatory Pest Control Applicator
4. Seed Treatment Pest Control Applicator or Operator
5. Livestock Pest Control Applicator or Operator
6. Fruit Crop Pest Control Applicator or Operator
7. Vegetable Crop Pest Control Applicator or Operator
8. Landscape and Turf Pest Control Applicator or Operator
9. Aquatic Weed Pest Control Applicator or Operator
10. Right-of-Way Pest Control Applicator or Operator
11. Forest Pest Control Applicator or Operator
12. Grain Facility Pest Control Applicator

The examination for the Illinois Custom Spray Applicators and Operators Licenses will be given by representatives of the Illinois Department of Agriculture at the end of the meeting. There is no fee for persons taking the licensing exam administered by the Illinois Department of Agriculture.

We look forward to seeing you and discussing problems of mutual interest. The following are the dates and locations for the clinics:

Date	City	Location
February 13	Jacksonville	Black Hawk Restaurant
February 14	Collinsville	Holiday Inn
February 15	Marion	Holiday Inn
February 16	Mt. Vernon	Holiday Inn
February 17	Effingham	Holiday Inn
February 20	Decatur	Holiday Inn
February 21	Macomb	McDonough 4-H Center
February 22	Galesburg	Holiday Inn
February 23	Sterling	Emerald Hills Country Club
February 24	Bloomington	University Union, Illinois State University
February 27	Champaign	Ramada Inn
February 28	DeKalb	DeKalb County Farm Bureau Building
March 1	Morris	Holiday Inn

The registration fee will be $1 per person. The *1978 Illinois Custom Spray Operators Training School* manual will be available for $6.00. The *Illinois Pesticide Applicator Study Guide* can be purchased at the clinic or from your local county Extension adviser for $1.00. Luncheons are extra.

The program for the clinics is shown below.

PROGRAM

8:15 a.m. Registration, Coffee, Get Acquainted

8:40 Welcome. . . . .*Host County Extension Adviser*

8:45 Pesticide Study Session—A Review for Agricultural Applicators and Operators Taking Certification Exams

Understanding Pesticides . . . . *John Wedberg*

Safe Handling of Pesticides. . . . .*Marshal McGlamery*

Application Equipment and Calibration. . . . . *Loren Bode*

Questions and Answers

9:55 Break

10:00 Seed Treatments For Field Crops. . . . . *Barry Jacobsen*

10:20 Controlling Problem Weeds. . . . .*Marshal McGlamery*

10:45 Precise Application With Flotation Equipment . . . . *Loren Bode*

11:10 Controlling Rootworms and Other Corn Insects . . . .*Don Kuhlman*

11:35 Update on Soybean Cyst Nematode and Plant Diagnostic Clinic. . . . . *Barry Jacobsen*

11:45 Black Cutworm Control. . . . . *John Wedberg*

11:50	Restricted Use Pesticides.	*Juett Hogancamp*
12:00 p.m.	Lunch	
1:00	Insect Control in Soybeans and Forages	*John Wedberg*
1:25	Improving Herbicide Performance.	*Marshal McGlamery*
1:45	Application Techniques To Avoid Herbicide Carry-Over	*Loren Bode*
2:05	Foliar Fungicides for Field Crops.	*Barry Jacobsen*
2:20	Grasshopper Prospects for 1978	*Don Kuhlman*
2:25	Illinois Pesticide Laws and Regulations.	*Juett Hogancamp*
2:35	Examinations for Agricultural Custom Spray Applicators and Operators Licenses	*Juett Hogancamp*

Prepared by the Agricultural Pesticide Dealers and Applicators committee of the College of Agriculture, University of Illinois at Urbana-Champaign, Illinois Natural History Survey, and State Department of Agriculture, Division of Plant Industries.

1978 URBAN PESTICIDE DEALERS AND APPLICATORS CLINICS

Sponsored by the College of Agriculture, University of Illinois at Urbana-Champaign, Illinois Natural History Survey, and the State Department of Agriculture, Division of Plant Industries

As a pesticide dealer or applicator, you are invited to attend one of the following area pesticide clinics. These meetings are a continuation of past years' dealer meetings and then dealer and applicator clinics. The day's program is geared to those persons who sell or apply pesticide to nonagricultural areas such as golf courses, home landscape plantings, parks, city streets, highways, industrial plant sites, and similar areas. Below are the dates and locations of the clinics. You are welcome to attend one of these meetings, and we will look forward to seeing you and discussing any pest problems you may have.

Date	City	Location
January 9	Champaign	University Inn Green and Third Street
January 10	Peoria	Heritage House Rt. 88 North
January 11	Springfield	Department of Agriculture Building (4-H Building), State Fairgrounds
January 12	Belleville	Belleville Area Junior College Rt. 161 East and Green Mount Road
January 13	Marion	Holiday Inn I-57 and Rt. 13
January 16	Macomb	4-H Center 1 mile west on Rt. 136
January 17	Moline	Holiday Inn I-280 and Airport Exit
January 18	Rockford	Rock Valley Community College 3301 Mulford Road
January 19	Rosemont	Sheraton-O 'Hare Motor Hotel 6810 North Mannheim Road
January 20	Joliet	Holiday Inn South Larkin and I-80

Advance registration is required for the meeting at Rosemont. Contact Ferdinand Arndt, 1475 Oakwood, Des Plaines, Illinois 60016 The registration and meal charge is $13.00. At the other nine locations, there will be a charge of $4 at the time of registration to cover the cost of a manual of educational material and a meeting room charge.

PROGRAM

9:00 Questions and Answers Regarding Program Agenda, Exams, and Pesticide Laws

9:25 Welcome

Session A

9:30 Turfgrass Pest Programs of 1977 and Control

10:10 Insect Problems of Trees and Shrubs and Control

10:50 Disease Problems of Trees and Shrubs and Control

11:20 Weed Problems in Ornamentals and Control

11:50 Lunch

1:00 Getting the Most From Your Spraying Equipment

1:40 Questions and Answers

2:00 Informal Discussion of Horticultural Pest Problems

Session B

9:30 Equipment for Right-of-Way Weed Control

10:10 Right-of-Way or Noncrop Weed Control

10:50 Aquatic Weed Control

11:20 Home Vegetable and Fruit Insect Control

11:35 Nozzle Tip Selection for Effective Spray Patterns

11:50 Lunch

1:00 Dutch Elm Disease Control Update

1:15 Household Insect Control

1:25 Mulches and Their Uses

1:40 Questions and Answers

1:45 Understanding Pesticides, Toxicity

2:15 Safe Handling, Labels

2:45 Examination

Speakers who will appear at the clinic are Loren Bode, Department of Agricultural Engineering, Robert Hiltibran, Illinois Natural History Survey, Juett Hogancamp, Illinois Department of Agriculture, Roscoe Randell, Department of Agricultural Entomology, Malcolm Shurtleff, Department of Plant Pathology, John Street, Department of Horticulture, and Dave Williams, Department of Horticulture.

The present Illinois law requires a person who applies a pesticide for hire outside a structure to be licensed by the Illinois Department of Agriculture. The Urban Clinic Program will cover information which will aid in training persons wishing to take exams in the following categories: forest pest control, ornamental and turf pest control, aquatic weed pest control, and right-of-way pest control. Exams for other categories will be available at the meetings.

The examination for the Illinois custom spray applicators and operators licenses will be given by representatives of the Illinois Department of Agriculture at the end of the meeting. There is no fee for persons taking the licensing exam administered by the Illinois Department of Agriculture. Anyone who has a license issued prior to 1973 will be required to take the new certification examination by October, 1977.

NEWSLETTERS FROM THE UNIVERSITY OF ILLINOIS COLLEGE OF AGRICULTURE

Farm Economics Facts and Opinions: Economic Principles applied to farm problems as pricing strategy, crop production costs and market outlook. Issued monthly.

Illinois Farm and Food Outlook: Anticipates reports and interprets current market information--supply, demand and price outlook--for agricultural products. Issued weekly except for last two weeks of December.

Agronomy News: Provides timely information on crops and soils. 10 issues per year.

Bees and Honey: Timely tips on bees, honey production and management. 10 issues per year (none in June or July).

Swine Report: Current information on feeding, management, economics and engineering. Issued quarterly.

Beef Report: Current information on feeding, breeding management and engineering. Issued quarterly.

Sheep Report: Timely management suggestions and educational activities. Nine issues per year.

Meat Report: Current research and educational events for meat industry; for all meat packers, processors and others in the meat industry. Issued bi-monthly.

Monthly Poultry Suggestions: Latest information on management, marketing, business and regulatory developments in the poultry industry for hatcherymen, commercial poultrymen, small flock owners and poultry servicemen. Issued monthly.

Insect, Weed, & Plant Disease Survey Bulletin: Weekly reports on situation and recommendations for control of insects, weeds and plant diseases. Issued weekly, March 25 - August 25. 20-22 issues.

Spray Service Report: Provides information on commercial fruit culture, insect and disease problems and recommended control measures. Issued weekly March - May, bi-weekly June - August 15, with special issues September - February.

Illinois Dairy Herd Improver: Provides dairy feeding, breeding and management information; lists USDA sire summaries of bulls, and other dairy news. Issued bi-monthly.

Illinois Vegetable Farmers: For commercial vegetable growers; growing, production and marketing conditions and legal aspects. Nine issues per year.

Illinois Nursery Notes: Nursery news and timely tips for commercial nurserymen and landscape contractors. Issued quarterly.

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_______	.50	VAS 4027a	Growing Wheat (24p)
_______	.40	VAS 4056	Wheat Diseases (20p)
_______	.30	VAS 4023b	Growing Oats (16p)
_______	.30	VAS 5021	Identifying Tree and Shrub Insects (16p)
_______	.55	VAS 5005b	Controlling Tree and Shrub Insects (28p)

OVERHEAD TRANSPARENCIES:

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UPDATE ON CORN DISEASES

M.C. Shurtleff, B.J. Jacobsen

The year 1977 was unusual at best with several of the same counties in Illinois applying for federal disaster relief for both droughts and floods. When the seemingly never-ending rains began in August, stalk and ear rot problems caused concern and aflatoxin dominated the headlines.

Wheat Streak Mosaic

Both sweet and field corn were seriously damaged in 15 counties east, north, and south of the East St. Louis-Collinsville area. Depending on time of infection, affected plants were somewhat stunted to severely dwarfed with little or no seed set, while some produced normal yields. The earlier the infection, the more severe the yield loss. The symptoms were difficult to differentiate visually in the field from those produced by the maize dwarf mosaic and maize chlorotic dwarf viruses. The wheat streak mosaic and maize dwarf mosaic viruses were occasionally found in the same corn plant; such infections resulted in the most severe symptoms.

Losses of 40 to 60 percent of the sweet corn crop because of the wheat streak mosaic virus occurred in many fields where volunteer wheat was allowed to grow after the soybean double-crop was harvested, where wheat was planted before the fly-free date, or where wheat was grown adjacent to or near corn. Wheat streak mosaic and its wheat curl mite vector are easily controlled by planting wheat *after* the fly-free date, destroying volunteer wheat one to two weeks before planting in the fall, and separating wheat and corn fields as far as possible.

Other wheat diseases at least partially controlled by late fall planting include soil-borne mosaic, barley yellow dwarf, Septoria diseases, leaf rust, and powdery mildew.

Maize Dwarf Mosaic

The MDM-strain A virus was fairly prevalent in the southern third of Illinois where johnsongrass is a common weed. It was also found on sweet corn as far north as Rochelle and Rockford in Illinois and in the St. Paul-Minneapolis area of Minnesota, hundreds of miles further north than it had ever been reported. We believe that tremendous numbers of aphids carrying the MDM virus were transported on southerly winds and then dropped into corn fields many miles from where they had fed on MDM-infected corn or johnsongrass. Since the MDM-strain A virus overwinters only in johnsongrass and very few other perennial grasses, it should not pose a serious threat to corn and sorghum in 1978 except where the disease has been a problem since the early 1960's. In southern Illinois, only resistant corn hybrids should be grown where johnsongrass is a weed in corn and sorghum fields or border areas.

Stewart's Disease

In spite of the severe winter of 1976-77, this disease was more prevalent than expected from mid-season on. Fortunately, only the late leaf blight phase was found over most of the state. Little or no yield loss occurred. Again, corn flea beetles, which transmit the causal bacterium, were probably carried on southerly winds to corn fields hundreds of miles further north than where the insect had overwintered. Growing hybrids resistant to Stewart's or bacterial wilt in the southern third or half of Illinois should largely control this disease in 1978.

Smut

Common smut was much more prevalent than normal throughout the state. It was not uncommon to find smut on 50 percent or more of all plants in certain fields. Most corn hybrids have some generalized resistance against the smut fungus, but this breaks down in years that are hot, dry, or windy, as we had in Illinois from mid-May to early August. However, many hybrids exhibited only minor infection even under these favorable conditions.

The most loss from smut, of course, comes from ear infections, where the loss may be 100 percent. The next most serious location of smut galls is on the stalk above the ear, followed by smut on the lower stalk. Galls on the leaves and tassel cause little or no loss. Smutty corn is safe to feed to all types of livestock.

Nematodes

These microscopic and transparent roundworms were again found damaging corn in many areas of Illinois. Lesion nematodes (*Pratylenchus* spp.) were the most prevalent and serious, followed by dagger (*Xiphinema* spp.) and needle (*Longidorus* spp.) nematodes.

Symptoms of nematode damage are very easily overlooked and confused with those produced by drought or excessive soil moisture, low or unbalanced fertility, and insect injury. Nematode-damaged corn plants are stunted, yellow, and lack vigor. The root systems on such plants are shallow and restricted with stubby, "nubbed off," and excessively branched feeder roots. Late in the season it is almost impossible to separate nematode damage from that produced by corn rootworms or by root-rotting fungi. The only positive was to identify nematodes as the primary cause is to have the feeding roots and surrounding soil examined by a trained nematologist working in a well-equipped laboratory (such as that provided by the Plant Clinic at the University of Illinois at Urbana-Champaign.)

Nematode injury to corn was most serious on sandy soils and in rolling fields, especially where corn had been grown more or less continuously and where minimum tillage or no-till was practiced. Here the nematodes, which are concentrated in the top 2 or 3 inches of soil, have a golden opportunity to start feeding on the first roots produced by seedling corn plants. Clean moldboard plowing in the fall is detrimental to overwintering nematode populations. With lower spring populations of nematodes, corn seedlings get off to a much better start.

Research at Iowa State University (see the article by Dr. Don C. Norton in this manual) and at the University of Illinois have shown good control of corn nematodes, increasing yields by 10 to 20 bushels per acre, by applying certain insecticide-nematicide materials (for example, Furadan) at planting time, the same as for corn rootworm control. About twice as much of the corn rootworm insecticide-nematicide is needed to control nematodes as to control rootworms. The specific use of a nematicide should be limited to corn fields where nematodes have been identified as causing a problem. Research on nematodes in corn and their control is still in progress at Illinois, and the subject will be discussed at winter agronomy and crop protection meetings. At this writing (early November 1977), our research plot data have not been completely summarized and statistically analyzed because of a late harvest.

Common Rust

This disease was again prevalent throughout the state on susceptible hybrids. Corn breeders and plant pathologists are concerned over the buildup of rust in the past two years, and more generalized rust resistance is being put into commercial hybrids. In some autumns that are unusually wet, rust helps to "dry down" corn plants, allowing farmers to harvest susceptible hybrids a little earlier than resistant ones--provided that combines can be operated in such fields.

Stalk Rots

The stalk- and root-rot complex, largely caused by *Pythium*, anthracnose, charcoal rot, both species of *Gibberella (Fusarium)*, *Diplodia*, and *Nigrospora*, was the most serious in the past 10 years or more, in spite of breeders' incorporating excellent stalk rot resistance into most commercial hybrids. Hybrids with marginal stalk rot resistance tend to break down when the early part of the growing season is hot and dry (putting the plants under stress), where insect and other injuries are more widespread and serious than normal, and when the weather is warm and wet from early August to harvest. Once cells in the pith of corn stalks begin to die, stalk rot fungi rapidly colonize the tissues, leaving only the vascular strands. It was not uncommon in 1977 to have 50 percent or more lodged stalks at harvesttime, especially where corn growers could not get into these fields to harvest.

Anthracnose stalk rot and leaf blight were widespread in central Illinois. While the disease was obvious on certain widely planted hybrids, the disease developed too late to reduce grain yields, although harvest losses from lodging were a problem in some fields. The widespread occurrence of anthracnose on certain single-cross hybrids with similar inbred parents only serves to once again demonstrate the dangers of genetic uniformity.

Ear Rots

Many of the fungi involved in the stalk- and root-rot complex also cause ear rots. Ear rots reported by Dr. Edward Jordan, the new survey plant pathologist assigned to Illinois by the EPA, include *Diplodia*, both species of *Gibberella (Fusarium)*, *Nigrospora*, *Cladosporium*, *Trichoderma*, *Penicillium*, *Aspergillus*, *Gonatobotrys*, and *Rhizopus*.

Ear rot losses are much greater where the rainfall is above normal for four to six weeks before harvest, as it was in 1977. Rainfall within 20 days of silking is critical to the development of "Gib" ear rot. Losses were also greater than normal last season because insects chewed off the silks and fed in the ears, especially the tips. Ear- and stalk-rotting fungi are common on the mouth parts, bodies, and the feces of all insects that feed on corn.

The most serious ear rot, especially for farmers who raise hogs and other livestock, are the two caused by *Gibberella (Fusarium)*. These fungi produce mycotoxins that are very poisonous to swine and to a lesser extent to other animals, especially those that are young or pregnant. *Gibberella (Fusarium)* will be the reason for "hog refusal" of shelled and ground corn this year and slowed-down weight gains. Hog farmers will in some cases be forced to use other types of feed to get their hogs to market.

Gibberella (Fusarium) is also a major cause of seedling blight and scab of small grains, especially wheat. If possible, cereals should not be planted in fields where *Gibberella (Fusarium)* was a serious problem on corn in the past two years; likewise, corn should not follow small grains.

Deep and clean moldboard plowing will speed up the decay of corn refuse left in the field, and there will be less carryover of the causal fungi. Fall plowing down of corn debris is preferred over spring plowing. But farmers must consider whether they expect to lose more in yield or forage from diseases or from combined soil-wind erosion and base their decision on this.

Given warm, moist weather in late summer and early fall in 1978, we will again expect stalk and ear rots to be severe. Expect the greatest loss to occur in fields planted more or less continuously to corn and where reduced or no tillage is practiced.

Aflatoxin

This mycotoxin was very much in the news last fall, especially in areas of southeast and central Iowa that experienced a severe drought in 1977. Aflatoxin is produced largely by the fungus *Aspergillus flavus* (a yellowish-green mold), although several species of *Aspergillus* and other storage mold fungi also produce this potent toxin. Unfortunately, many country and terminal elevators used a black light to reject truck loads of corn. All a black light indicates is whether *Aspergillus flavus* is present. The black light is less than 50 percent accurate in picking out grain that has aflatoxin in measurable amounts (2 parts per billion or more). *A. flavus* produces a compound (BGYF) that shows a distinctive greenish-yellow "glow" under a black light. Besides having a distinctive "firefly-like" color, the BGYF compound is water-soluble. These characteristics help distinguish BGYF fluorescence from other naturally occurring fluorescent compounds.

A packet of news articles looking at the aflatoxin problem from all angles--effects of feeding to various types of animals at various levels, feeding alternatives, how to sample and detect, a listing of laboratories that test for aflatoxin, the chemical tests that are available and their accuracy--was written by a dozen extension-research specialists at the University of Illinois at Urbana-Champaign and sent to each county extension office. Every farmer who feels he has an aflatoxin problem should contact his local county extension adviser for information.

Storage Molds

Aspergillus flavus and other aflatoxin-producing fungi are rare in Illinois corn fields, being almost entirely a problem in stored, shelled corn. *Farmers are strongly urged* to check their stored corn at about weekly intervals this winter, spring, and summer by probing for "hot spots" that indicate storage mold activity. We expect the real aflatoxin problem to develop in late winter and spring as the grain warms up naturally.

Aspergillus flavus has an optimum growth at temperatures of 70° F. and above and at a grain moisture content in the range of 15 to 18 percent. If hot spots are found, such grain should be immediately stirred or moved to release the heat and moisture that storage mold fungi require to invade corn. The grain should then be promptly dried down to 13 percent moisture.

There are 25 or more fungi, mostly species of *Aspergillus* and *Penicillium*, that cause corn to go out of condition and rot. These fungi act within rather narrow limits of temperature and grain moisture. A few storage fungi can attack corn (especially with cracked and broken kernels) at 12 percent moisture or slightly below and a temperature of 40 to 50° F. Most storage mold activity, however, does *not* occur until the moisture is above 14 percent and the temperature is 60° F. or above. Invasion and rotting of corn are greatly accelerated as the moisture content and the temperature rise. Rotting at 15 to 18 percent moisture and 70 to 90° F. is 50 to 100 times more rapid than at 13 to 13.5 percent moisture and a temperature of 40 to 50° F.

It is also important to know that stored wheat, oats, sorghum, soybeans, and other farm products are attacked by the same complex of storage molds; these grains often produce aflatoxin and other mycotoxins at moisture contents above 13 or 14 percent and a temperature above 40 to 50° F.

Leaf Blights

Race 0 of southern corn leaf blight (caused by *Helminthosporium maydis*) was common on susceptible hybrids in the southern third of Illinois again in 1977 but caused little yield loss. The same could be said of northern leaf blight (*H. turcicum*) in the northern half of the state. Many hybrids are available that are resistant to both leaf blights, especially northern. There is no excuse for a farmer to plant a corn hybrid susceptible to northern or southern leaf blight when there are literally hundreds of highly resistant hybrids available with excellent yield potential, coupled with good stalk rot resistance and other desirable agronomic qualities.

Other fungal leaf blights that were more common than usual in 1977 include anthracnose (*Colletotrichum graminicola*) and Helminthosporium leaf spot (*H. carbonum*). These fungi can also produce a black ear rot that closely resembles that produced by Race T of the southern leaf blight fungus. Breeders are working to put more anthracnose and Helminthosporium leaf spot resistance into commercial hybrids.

WHAT'S NEW IN WEED CONTROL

M.D. McGlamery

There were few new herbicides fully registered in 1977, but there will be several new herbicides with experimental use permits (EUP). An EUP allows field-scale testing before full registration.

Soybean Herbicides

Antor (H-22234) from Hercules and Butam (G-4455) from Gulf are acetanilide herbicides that will have EUP's for preemergence grass control in soybeans. The Antor EUP will allow use with Lorox or with metribuzin (Sencor or Lexone). Goal (oxyfluorfen), formerly RH-2915, is a diphenyl ether herbicide from Rohm and Haas. It is similar to Modown (bifenox) but will have higher specific activity. Its EUP will probably be for both preemergence and preplant use.

Hoelon (Hoe-23408) is a postemergence herbicide from American Hoescht. It had an EUP in 1977 and will have one again in 1978. It controls foxtails (giant, yellow, and green) and barnyardgrass at the 1 to 4 leaf stage and appears promising for control of volunteer corn.

Prowl will have EUP's on 15G and 75W formulations in 1978. Lexone and Sencor (metribuzin) will both have 4 pound per gallon liquid formulations available in 1978. There are slight differences in their formulation but little difference in their activity. Lexone 4L is registered with Treflan, Prowl, and Lasso, while Sencor 4F (flowable) is registered with Treflan, Lasso, Surflan, and Prowl.

Several new tank-mix soybean herbicide combinations have been or are soon expected to be registered. Prowl and Tolban now both have registrations for tank-mixing with Lexone 50W or Sencor 50W for preplant incorporation. Amiben plus Sencor is labeled for preemergence use in soybeans. Amiben plus Treflan may have clearance for a tank-mix combination by planting season. Several companies are beginning to register sequential treatments even though the EPA has not yet mandated such combinations in time to be registered.

Tolban and Basalin now have double-rate (2X) treatments for reduction of established johnsongrass. Tolban also has a high rate for wild cane control and morningglory suppression and has redefined its rates of application based on soil organic matter and texture.

No-Till Soybeans and Corn

Several new treatments have been registered for no-till soybeans. Dow General (dinoseb) has been labeled as a knockdown herbicide for soybeans grown in small grain stubble. Its activity varies greatly with temperature. Herbicides newly cleared with Paraquat are Lasso plus Lorox, Sencor alone or with Lasso, Surflan plus Lorox, and Surflan plus Sencor.

Roundup has been registered for use in no-till soybeans with Lasso plus Lorox and in no-till corn with Lasso plus atrazine. Roundup is a translocated herbicide, not a contact herbicide; thus, the kill of existing vegetation will be slower than with Paraquat or Dow General.

Corn Herbicides

Basagran is now registered as a postemergence herbicide for use in corn as well as soybeans. Corn tolerance is exceptionally good. Dual alone or with AAtrex is now registered for preplant incorporation as well as preemergence. Banvel plus Lasso is cleared for early postemergence use (corn under 3 inches) as well as preemergence use. Bladex plus atrazine is labeled for preplant incorporation as well as preemergence use.

New tank-mix combinations for corn are Eradicane plus atrazine and Eradicane plus Bladex for preplant incorporation. Eradicane and Sutan labels now approve sequential postemergence treatments with 2,4-D.

Several corn herbicides have had label and formulation changes. Prowl alone or with atrazine or Bladex is now registered for preemergence use in corn on soils with less than 1½ percent organic matter and on sands and loamy sands. Sutan has a new 7-1/3-pint rate for wild cane or yellow nutsedge control and for rhizome johnsongrass suppression. Dual has a rate change for coarse soils with more than 3 percent organic matter. Bladex plus atrazine combinations are now cleared for 3:1, 2:1, and 1:1 ratios, depending upon the degree of grass infestation expected. Sutan+ 10G and Sutan+ plus atrazine 18-6G have safener added to the formulation.

Other Label Changes

New clearances for impregnation with dry fertilizer are Sutan+ alone or with atrazine, Eradicane, and Tolban. Dual alone or with AAtrex and Tolban alone are cleared for use with liquid fertilizer as a spray carrier.

Amex and Lasso-Atrazine 15G will no longer be manufactured. Existing supplies of these are still registered and should be used.

Herbicides currently listed as restricted for use to certified applicators are Paraquat and Tordon. Most aquatic herbicide uses will probably be restricted. Aqualin is already restricted, and Diquat and Endothal will probably be classified as restricted.

1977 Problems in Weed Control

Spring rainfall was scattered and scarce, so effectiveness of preemergence herbicides was somewhat variable, depending upon the local rainfall. Much of the corn was planted in late April; locally heavy rains occurred on May 4 and 5, causing crusting and some Lasso injury. Later we had many questions in late May or early June about poor corn rooting. This was caused by hot, dry soil, not by herbicides.

Atrazine carryover injury to soybeans was the greatest in many years. This was expected because of the cool, dry 1976 growing season. Atrazine carryover is not expected to be nearly so severe in 1978. The additive effect of Sencor, Lexone, Lorox, or Maloran with atrazine carryover was also noticeable in many soybean fields.

Broadleaf weed control was a problem in many corn and soybean fields because of the low rainfall. Postemergence herbicide use was greater in both corn and soybeans. Banvel and 2,4-D drift to soybeans was a problem in several areas. Because of high temperatures in June, Dyanap and Basagran caused more soybean burning than would normally be expected. The need for early application of Basagran, especially for velvetleaf control, was evident.

Late-emerging weeds were more of a problem in 1977 because of the late rains in August and September. Late grasses were evident in many corn fields at harvesttime. Prickly sida, virginia copperleaf (three-seeded mercury), and black nightshade were commonly reported in soybeans.

There is still need for a herbicide that will control volunteer corn in soybeans -- "succotash" fields were common in many areas. Harvest-aid treatments of Paraquat in soybean fields were used in many areas for the first time because of the weedy fields and the early maturity of soybeans.

PREDICTING AND CONTROLLING BLACK CUTWORMS

F.T. Turpin

The black cutworm in its larval stage is a sporadic pest of corn in most Midwestern states. However, each year some cornfields are extensively damaged, resulting in stand losses that can reduce yield and sometimes necessitate replanting the crop. Many corn producers are concerned about the potential for black cutworm damage, especially since none of the currently used "rootworm" insecticides has been shown to consistently control economic infestations of black cutworm larvae.

Black cutworm larvae are not specifically pests of corn. They attack seedling corn mainly because choice of food plants in a cornfield is severely limited. Black cutworm moths are nocturnal insects and apparently oviposit in or near the areas where they spend the daylight hours. Tests have shown that, when exposed to gravid moths, low-growing dense vegetation received more cutworm eggs than did sparse vegetation or plant debris, and that bare soil received few eggs. Sherrod *et al.* (1977 Illinois Custom Spray Operators Training School, p. 59-61), summarized field characteristics that appear to be related to field infestations of black cutworm larvae in Illinois.

The following data, summarized from Indiana, Illinois, Ohio, Iowa, and Missouri, agree favorably with the Illinois results and provide useful guidelines for determining fields likely to have cutworm populations:

1. Fields adjacent to permanent vegetation (woods, river bottom lands, pastures) provide sites for overwintering.
2. Corn following soybeans in rotation determines tillage season and type, weed populations, and crop residue.
3. Late-planted fields are more likely to develop a preplant weed population, which is often attractive to moths ready to oviposit.
4. Spring tillage increases the weed population.
5. Minimum tillage increases the weed and residue density.
6. The presence of preplant weeds increases the number of favorable places for oviposition.
7. Factors showing no relationship to black cutworm populations include insecticide usage, soil pH, soil nutrients (N, P, K), soil drainage, and soil type.

The highest probability for cutworm damage occurs where corn follows soybeans, and when fields are spring tilled or minimum tilled. In addition, the risk of cutworm damage is increased in fields adjacent to areas with permanent vegetation, such as river bottom land, and in fields having high weed populations before spring tillage. Fields that are to be planted to corn and that have one or more of the above characteristics should be considered potential cutworm fields.

If a field is considered a high risk for cutworm damage, the control options are the application of an insecticide at planting time or, in the event that infestation

Table 1. Control of Black Cutworm Larvae After 7 Days of Exposure to Soil Treated With Heptachlor and Diazinon

Product	Percent dead larvae by instars					
	1	2	3	4	5	6
Heptachlor, 1.5 lb. a.i./A.	78	60	50	55	25	5
Diazinon, 4.0 lb. a.i./A.	55	40	50	30	40	15

Table 2. Plant Population and Yields Resulting From Application of Mocap and Lorsban to Cutworm-Infested Field at Planting on May 20, 1977

Product (granules)	Rate, oz. a.i./ 1,000-ft. row[a]	Plant population/A.[b]	Yield increase over untreated plot[c]
Mocap	1.2	9,163	5.5%
Lorsban	1.2	18,027	68.9%
Untreated	. .	6,476	. . .

[a]Applied as 7-inch band in front of press wheel.
[b]Counts based on 10 samples of 100-foot row per treatment.
[c]Based on machine harvest.

develops later, a postplant application as soon as the insect is detected. Insecticide applications at planting time have shown variable control results for years. The rather inconsistent control results are probably due to a variety of factors including the decreasing susceptibility of cutworm larvae to insecticides through their larval instars (Table 1).

The performance of any insecticide application may reflect the percentage of the cutworm larval population in each instar at the time of treatment. Two insecticides currently labeled for application at planting time for cutworm control are to be used on "low to moderate" infestations, a restriction that most likely results from variable performance data for the insecticides. Such a restriction is of little value since, to the best of my knowledge, it is impossible to predict the level of a cutworm infestation. Control results of Mocap and Lorsban (1.2 ounce active ingredient per 1,000-foot row) on black cutworm in Indiana are shown in Table 2.

Postplanting insecticide applications provide a viable alternative to planting treatments. The key to the success of such treatments is timely application, that is, before significant damage has occurred. Deciding when to begin treatment can be accomplished by scouting high-probability fields during seedling growth. In some instances the young cutworm larvae climb the plants and feed on leaves before beginning to cut the plants. Evidence of such feeding is useful in detecting the cutworm population while damage is slight and control easiest to achieve.

A total management program for black cutworm larvae should be based on the probability of a field infestation, combined with scouting activities in high-risk fields. With this information, control benefits can be maximized, because insecticides would be applied only to fields where the risk of yield loss is high, thus reducing the use of preventive treatments that are often unnecessary.

SYMPTOMS OF MISAPPLIED ROW CROP HERBICIDES

V.M. Jennings

Many interacting factors govern the effectiveness of herbicides and the potential for crop injury. Described in this paper are interaction of environmental conditions such as rainfall, temperature, and relative humidity; managerial factors such as depth of planting, time of planting, time of application, and general tillage practices in seedbed preparation; weed species present in the field; and rate and kind of chemical needed to provide greatest economic return from the crop.

Trade names are used in describing various symptoms of misapplied herbicides for clarification in explaining the use of the chemical involved. Inclusion of a trade name does not imply endorsement of that particular brand of herbicide, and exclusion does not imply nonapproval. Various herbicides are divided into chemical classes or families in Table 1 to aid in comparing similar herbicides.

Table 1. Chemical Classification of Herbicides

Chemical classification	Trade name
amides	Lasso, Alanap, Ramrod, Benton, Propachlor, Dual, Antor
benzoics	Amiben, Banvel
bipyridiliums	Paraquat
carbamates	CIPC, Furloe
diazines	Basagran
dinitroanalines	Surflan, Treflan, Cobex, Tolban, Basalin, Prowl, Sonalan, Rydex
diphenylethers	Modown, Goal
phenols	Premerge, Dyanap
phenoxys	Butoxone, Butyrac, 2,4-D
thiocarbamates	Sutan+, Eradicane, Vernam
triazine	Evik, AAtrex, Atrazine, Bladex, Princep, Sencor, Lexone
ureas	Maloran, Tenoran, Lorox
unclassified	Roundup

Solubility, Adsorptivity, and Persistence of Herbicides

Many herbicides vary greatly in water solubility and adsorptivity, which is often why they work well in one situation and poorly in another. There may also be a basis for crop injury under heavy rainfall.

Some herbicides persist in the soil too long and carry over to the following year; others may not remain in the soil long enough to control weeds effectively if applied too early. Factors affecting persistence are volatility, photodecomposition, adsorption, leaching, plant uptake, microbial decomposition, and chemical decomposition. Depending upon soil type, one or all of these factors may affect an herbicide; therefore, an exact length of persistence cannot be determined.

Table 2 lists various herbicides, their solubility in water, how tightly they are held by soil colloids, and their persistence in the soil.

Method and Symptoms of Herbicide Injury

Amides

Herbicides in the amide chemical family (also commonly referred to as acetanilides) inhibit root and shoot growth, causing stunted, malformed seedlings. Amides interfere with normal cell division and elongation and disrupt protein synthesis.

Uptake of most herbicides in this class can occur through roots, shoots, and seeds. The herbicides must be present in early stages of germination and growth to be effective.

These herbicides are most effective on grassy weeds. Injury symptoms to corn from misapplication of these herbicides include leafing-out underground and failure of leaves to unfurl properly. Soybean injury from these herbicides occurs in the form of a shortened midvein, which results in crinkling and a heart-shaped appearence.

Table 2. Solubility,[a] Adsorptivity, and Persistence[b] of Commonly Used Herbicides

Chemical	Water solubility (ppm at 20^{o}-27^{o} C)	Adsorptivity to soil colloids	Soil persistence at common use rates (months)
AAtrex	33	strong	2 to 8
Amiben	700	weak	1-1/2 to 2
Banvel	450	weak	1 to 1-1/2
Basagran	500	weak	1
Basalin	1	very strong	3 to 6
Bladex	171	strong	2 to 3
Cobex	1	very strong	3 to 4
Eradicane	370	strong	1-1/2 to 2
Furloe	88	very strong	1/2 to 1
Lasso	242	strong	1 to 2
Lexone/Sencor	1,200	moderate	2 to 4
Lorox	75	very strong	2 to 4
Paraquat	--	very strong	1
Prowl	1	very strong	2 to 6
Princep	5	strong	2 to 8
Ramrod,Bexton,Propachlor	700	moderate	1 to 1-1/2
Sutan+	45	very strong	1-1/2 to 2
2,4-D	600	moderate	1/2 to 1
Tolban	1	very strong	3 to 6
Treflan	1	very strong	3 to 6
Vernam	90	very strong	1 to 2

[a]Herbicide Handbook, Weed Science Society of America.
[b]Twenty-Ninth Illinois Custom Spray Applicators Training School Manual.

Benzoics

Benzoic herbicides cause abnormal root and shoot growth by upsetting plant hormone (auxin) balance. Uptake can occur through seeds or roots with soil-applied treatments or through leaves when applied postemergence.

Banvel is translocated throughout plants when applied to soil or leaves and accumulates in areas of high growth activity. It is primarily effective on broadleaf species.

Corn injury due to misapplication of Banvel occurs in the form of onion leafing, proliferation of inhibited roots, or abnormal brace root formation.

Soybeans are extremely sensitive to Banvel. Soybean injury from Banvel drift is characterized by cupping and crinkling of leaves.

Although related to Banvel, Amiben behaves differently. It is applied as a preemergence treatment and is taken up by germinating seedlings. It is not rapidly translocated and most of the herbicide remains in the root, where itcauses abnormal development and results in stunted plants. Misapplied preemergence Amiben may cause poor soybean germination and abnormal root development with many short-fused roots. This also results in stunted plants.

Bipyridiliums

These are nonselective contact herbicides. They rapidly disrupt membranes, resulting in wilting and tissue death. Light (through photosynthesis) increases activity of these herbicides by changing them to more active free-radical forms. There is very little translocation because of loss of membrane structure.

Injury occurs only where spray contacts the plants. Complete spray coverage is essential for weed control. Because the herbicide molecules carry strong positive charges, they are very tightly adsorbed by soil colloids and thus have no significant soil activity. Injury to crop plants from Paraquat drift occurs as spots of dead leaf tissue wherever spray droplets have touched the leaves.

Carbamates

These herbicides generally inhibit cell division or cause abnormal cell division. When applied to the soil, they are taken up by seeds, by shoots, and, to a lesser extent, by roots. Some upward translocation occurs. Crop injury from misapplication would occur mainly in the form of inhibited roots and stunted plants.

Diazines

Basagran belongs to the diazine class of chemicals. A postemergence herbicide, Basagran inhibits photosynthesis. It appears not to translocate within or out of the broadleaf weed leaf. It is different from many commonly used photosynthesis-inhibiting herbicides such as the triazines and ureas in that it has no soil activity and is apparently not absorbed by the roots, although it is soluble in water and weakly adsorbed by soil colloids. It is similar to the triazine and urea herbicides in producing the same leaf symptoms on weeds.

Dinitroanalines

These soil-applied herbicides are absorbed mainly by shoots and to some extent by roots. Very little chemical movement occurs within the plant, so the primary effect of the herbicides is on the roots. Uptake of these herbicides in vapor form may be important. Dinitroanaline herbicides inhibit cell division and inhibit lateral root formation.

Soybean injury from misapplication of these herbicides occurs in the form of root pruning. Roots that do develop are thick and short. Hypocotyl (the area of stem below cotyledons) swelling also occurs. The inhibited root growth causes tops of plants to be stunted, often with a dark green color.

Corn injured by carryover of dinitroanaline herbicides (such as Treflan) will show root pruning with short, thick roots. Leaf margins have a reddish tinge. Such injury is often spotty because concentrations of the herbicide are localized and do not move in the soil.

Diphenyl Ethers

When applied preemergence, diphenyl ether herbicides (for example, Modown) kill weed seedlings through contact action and membrane destruction as the seedlings contact the surface herbicide layer. These herbicides may also inhibit photosynthesis. Broadleaf weeds are affected more than grasses.

These herbicides are strongly adsorbed by soil colloids and move very little in soil. Injury can sometimes occur when driving rains splash treated soil onto leaves of newly emerged crop plants. When emerging soybean seedlings lack vigor because of cool, wet conditions or deep planting, Modown can sometimes cause stand reduction if hypocotyl tissue is killed as it emerges.

Phenols

Phenol herbicides, such as Premerge (dinoseb), act as contact herbicides and destroy plant membranes, resulting in leakage of sap and desiccation (drying). At lower rates they interfere with energy transfer within the plant.

When these herbicides are applied postemergence, warm temperatures and direct sunlight increase activity. Very little translocation occurs. Crop injury from postemergence phenol herbicides occurs in the form of leaf burn.

When phenol herbicides are applied preemergence, roots of germinating weeds are apparently destroyed before they develop appreciable foliage.

Phenoxys

Phenoxy herbicides cause abnormal growth by overloading the hormone (auxin) balance of plants. Broadleaf plants are much more susceptible to injury. Normal growth processes are stopped, and abnormal growth in the form of radial expansion and formation of callus tissue leads to loss of root function, plugging of phloem (stem veins), inhibition of photosynthesis, and eventual death.

Phenoxy herbicides are rapidly translocated by actively growing plants. They have both preemergence and postemergence activity and are taken up by foliage or roots. However, they are most commonly used as postemergence herbicides.

Injury to corn by 2,4-D usually occurs in the form of leaf rolling (onion leafing) or abnormal brace root formation; 2,4-D can also cause temporary brittleness of stalks, which may lead to lodging if high winds or cultivation follows application.

Soybeans or other broadleaf crops injured by phenoxy herbicide drift may have leaf veins that grow parallel to each other. Leaves often bend downward soon after treatment. Stems often become twisted.

Thiocarbamates

These herbicides inhibit cell division and cell elongation. They may alter plant hormone (gibberellic acid) distribution in plants. In grasses, they inhibit meristem activity (root and shoot growth) and cause abnormal emergence of leaves from the coleoptile (sheath that covers the shoot tip). Susceptible broadleaves are inhibited and their leaves become cupped. Uptake may occur through seeds, shoots, or roots, but shoots are more affected than roots. These herbicides are applied to the soil. Most are volatile and must be incorporated.

Corn injury from thiocarbamate herbicides, such as Sutan and Eptam, occurs where leaves do not properly unroll from the coleoptile. Leaves are stunted and twisted, often appearing knotted. In recent years, antidotes or safeners have been developed to help prevent thiocarbamate injury to corn. These may be used as seed treatments (Protect) or formulated directly with the herbicide (Sutan+ and Eradicane contain R-25788). The protective mechanism of these antidotes is not known, but they may enable corn to degrade the herbicides more rapidly.

Soybean injury from Vernam takes place in the form of slowed emergence and crinkling of leaves on small bean plants. Antidotes or safeners do not protect soybeans.

Triazines

Triazine herbicides inhibit photosynthesis. This leads to chlorosis or yellowing of leaves followed by necrosis or death of leaf tissue. A secondary substance formed as a result of inhibition of photosynthesis may be responsible for plant death. When such herbicides are applied to the leaves, uptake into the leaf occurs, but there is very little movement out of the leaf.

Triazine injury to corn occurs as yellowing of leaf margins and tips followed by browning. Triazine injury to soybeans due to atrazine carryover or misapplication of Sencor or Lexone occurs as yellowing or burning of outer leaf margins. The entire leaf may turn yellow, but veins usually remain somewhat green (intervenal chlorosis). Lower leaves are most affected, and new leaves may be unaffected.

Ureas

Urea herbicides inhibit photosynthesis similarly to the triazine herbicides. They are taken up by roots and move upwards throughout plants when applied to soil. If application is to leaves, uptake occurs with little movement out of leaves.

Injury from urea herbicides to corn or soybeans is very similar to injury caused by triazine herbicides. Yellowing occurs first at leaf tips and margins and is followed by browning. Severe injury may cause the entire leaf to turn yellow and die.

Soybeans injured by overapplication of Lorox or Maloran react as follows: After root uptake and translocation to the leaves, inhibition of photosynthesis occurs rapidly following exposure to sunlight. Affected seedlings die rapidly. Plants only slightly affected recover quickly and develop into normal plants. Roots are not affected and appear normal.

Unclassified

Roundup is a major herbicide that does not belong to common herbicide chemical families. It is a substituted amino acid that interferes with normal amino acid synthesis.

Roundup, which is nonselective, is very tightly held in soil so that no root uptake occurs. Applications must be made to foliage.

Translocation occurs out of leaves to all plant parts including underground storage organs of perennial weeds. Translocation is greatest when plants are actively growing. Injury symptoms are fairly slow in appearing. Leaves slowly wilt, turn brown, and die. Sublethal rates of Roundup can sometimes produce phenoxy-type symptoms with feathering of leaves (paralled veins) or proliferation of vegetative buds.

PESTICIDE ACCIDENT HISTORIES IN CALIFORNIA

R.W. Brazelton, K.T. Maddy, J.B. Knaak, C.S. Kahn

Forty years ago, an all-out insect attack often meant total crop failure. At that time, the list of weapons against insects contained only a few items, such as Paris green and some home recipes of questionable value based on folklore. Crop loss was common.

For a while, more modern chemicals such as DDT enjoyed some years of spectacular success against pests. They were relatively safe to handle, but with their continued use came problems. One by one, insect resistance, restrictive regulation, or both removed a number of them from the market place.

The insects and other pests remained, so new orders of chemical, including organophosphates and carbamates, were called upon. They were highly effective, to be sure, and they answered environmental needs, but some proved to be very toxic to the persons handling and applying them. This, then, led to the dilemma of how to use pesticides and keep the worker safe at the same time.

The situation was not good, but it was not nearly as bad as the widely quoted emotional opponents would have one believe. With no basis in fact, it was widely proclaimed that thousands were becoming ill and hundreds of persons were dying yearly from pesticide poisonings. The problem required solution.

The Development of Regulations

In California, with its vast commercial agriculture, pesticide exposure accidents were definitely happening, but facts could not be found to verify the widely proclaimed accounts of mass poisonings and possible deaths.

In 1973, in an effort to provide sound scientific data as a basis for realistic corrective action, the California Department of Food and Agriculture and the California Department of Health sent medical and toxicologic personnel into all of the state's counties to explore the details of observed and reported incidents of pesticide injury. Many reports proved quite accurate; others, while accurate in their reporting, were based on opinion or guesswork but were later proved related to other causes; and some were proved to be in error. This extensive effort proved beyond a doubt that many illnesses or injuries due to pesticides had occurred (1,474 cases in that year in California); it also confirmed that no death due to use of pesticides in agriculture had occurred that year.

While 397 of the 1,474 cases did not involve agricultural operations, the remaining 1,077 were considered to be too many in relation to the total work force. As a result, emergency pesticide worker safety regulations went into effect as of January 4, 1974.

Subsequently, the regulations were modified several times and the monitoring continued. It should again be noted that in 1974, 1975, and 1976 not a single occupational death occurred in California agricultural pesticide usage. Two occupational deaths as a result of gross negligence did occur in California cities when structural pest control employees used cyanide in attics without gas masks. Almost all deaths from pesticides in California (about 20 per year) are suicides.

These studies soon pinpointed the most hazardous operation. The heaviest injury rate was among those workers involved in daily actual pesticide-handling operations. Injuries were greatest among mixer/loaders, flagmen, ground applicators, field workers, nursery and greenhouse workers, gardeners, and others coming in close contact with toxic chemicals or their residues. Toxicity Category 1 organophosphates, among the most toxic, proved most hazardous. Carbamates were involved as well.

Corrective action was immediately focused on development of methods of preventing body contact with the valuable and highly useful pesticides that presented a toxicity problem. Dermal exposure appeared to be the greatest hazard, so field worker reentry restrictions were established early to protect field workers from decaying pesticide residues that often converted to more toxic breakdown products on foliage.

To protect mixer/loaders, closed system handling methods were proposed. Many complex problems were involved, for one cannot change an industry overnight. Although closed systems seemed to be the answer, none existed. Containers came in such a wide variety as to defy a uniform container entry method. Industry members gave the matter study, and prototype systems appeared. Closed system use by employees was required on a specific time schedule in 1977; by January 1, 1978, total conformance is required for Toxicity Category 1 liquid pesticides.

Further Studies of Pesticide Exposure

In the years since 1973, constant and much more effective followup studies of official reports of incidents of pesticide injury have continued. In addition, specific segments of the industry have been carefully reviewed. Specialized field studies have been directed at problem areas, and monitoring of activities converted to closed system use has been undertaken.

Studies of illnesses point out the causes. Table 1 clearly shows that injury or illness frequency increases with the degree of direct contact with Toxicity Category 1 and 2 materials. Mixer/loaders, ground operators, flagmen, field workers, nursery and greenhouse workers, and gardeners did indeed account for a large percentage of the illnesses.

Mixers and Loaders

Mixers and loaders were studied in 1975; 143 illnesses occurred in persons who did this job exclusively. Most incidents were related to splashing on skin or into eyes. Some inhalation problems occurred. Phosdrin and parathion were the worst offenders. Systemic injuries common to skin absorption were high. Three aerial applicator firms accounted for 20 percent of all cases, a fact that led to regulatory actions against each of them.

Of the total of 320 occupational illnesses that involved mixing and loading, the above 143 cases were exclusively related to mixing and loading alone. Eighty-one more were primarily involved in mixing and loading, but with some extra activity; the remaining 96, not clearly defined, may have been involved in mixing and loading along with other activities. Two-thirds of the injuries involved liquids. In the 271 cases where the source of illness could be identified, 49 percent involved Toxicity Category 1 materials.

Table 1. Number of Pesticide Illnesses (as first reported by physician)

	Total numbers by employment			
	1973	1974	1975	1976
Pilots	14	17	7	8
Flaggers	20	6	16	14
Loaders	165	141	143	122
Total for agricultural aircraft only	199	164	166	144
Agri. ground applicators	424	225	264	254
Field workers reentry	157	112	167	156
Gardeners (commercial)	66	103	106	159
Nursery and greenhouse	112	73	90	119
Fumgator (field)	71	29	22	14
Machine cleaning and repair	22	28	40	26
Tractor drivers, irrigators	..	23	22	30
Drift exposure	26	22	31	29
Others	..	7	1	19
Totals for agriculture (other then aircraft)	878	622	743	806
Total, all agriculture	1,077	786	909	950
Total, other than agriculture	397	371	434	502
Total for year	1,474	1,157	1,343	1,452
Agriculture percent of total	73	68	68	65

Ground Applicators

A 1975 study of ground applicators revealed 264 cases that year. Three counties with very heavy commercial agriculture accounted for one-third of the cases.(It is interesting to note that these same counties have been slow in developing general farm-safety programs.)

This study showed that most serious exposures follow mixer/loader accidents. Ground applicator exposure increased because of mixer/loader and application activities. The hot climate caused skin and inhalation problems on hot days. Clean clothing, clean protective equipment, and frequent, thorough washing of the worker proved important in heavy work periods. The highly toxic Category 1 liquids figured high in illness causation.

The 1975 study of ground applicators resulted in recommendations for closed systems for all Category 1 liquids, dust-free powders or the use of soluble bags around highly toxic powders, and respiratory protection.

Gardeners and Maintenance Workers

In 1976 a study of injuries and illnesses involving gardeners and maintenance workers indicated 159 cases: 41 systemic reactions to a wide variety of pesticides, 67 eye injuries (primarily with fungicides), 47 skin injuries, and 4 skin and eye combination injuries, also from fungicides. The study again reflected carelessness, disregard for safety procedures, and system failures from poor equipment and maintenance. Almost every injury or illness cause is covered by one or more of the regulations now in force.

Aerial Applicators

Illnesses of aerial applicators were studied in 1976. Only eight cases occurred. This number was low probably because pilots have to show competency in pest control to obtain a license, pilots are not permitted to load their own planes in California, and regulations require elimination of potential hazards within the plane. The aerial applicator releases the material below and behind his aircraft; unless he flies back through it, he is relatively safe. The accidents that did occur were exposures that occurred during crashes, because of equipment failure, and because of carelessness while on the ground.

Phosdrin

Phosdrin is an example of a highly toxic organophosphate. This pesticide is highly effective in pest control, but with an oral LD_{50} (rat) of 3.7 to 6 mg/kg and dermal LD_{50} (rat) of 4.2 to 4.7 mg/kg, it is very hazardous in handling operations. Xylene, which is sometimes used as a solvent, enhances Phosdrin's toxicity. In spite of its hazard, the record is interesting. During 1961 to 1973 three deaths were caused by Phosdrin (there have been none since 1973). Two involved ground workers and spilled material. The third involved a plane crash caused by poor pilot judgment, followed by clothing saturation and no emergency treatment despite the presence of coworkers. In 1975 there were 76 nonfatal exposures, 69 of which were systemic illnesses primarily involving formulators, mixer/loaders, and ground applicators. In 1976, the 68 nonfatal exposures that occurred followed the same pattern.

Fatalities

In agricultural use, *no* fatalities resulted from pesticides in California in 1973, 1974, 1975, 1976, or in the first 10 months of 1977, the dates for which data are available for this paper. When this is compared to the 38 tractor accident deaths in 1976 alone, it is rather clear that the emotional emphasis on pesticide deaths may be misplaced.

Illness and Injuries

Detailed studies prove that most illnesses and injuries result from one or more of several physical conditions that could be controlled by compliance with effective regulations. This is an old story, long in evidence in the development of industrial safety orders. That is, regulations, safety orders, and rules always result when accident occurrences reach an unacceptable level, and these regulations individually relate to specific accident types. It should be noted that the studies referred to above involve activities before extensive use of closed systems since this regulation does not become totally effective until 1978.

Some Medical Findings

Nature of Reported Illnesses

S.A. Peoples, M.D., University of California, evaluated occupational pesticide illnesses in California. In 1975, he noted a number of relationships too extensive to report in detail here, but briefly, of the 1,746 officially reported illnesses submitted, 240 involved firemen and policemen who were exposed to pesticides at accident sites but did not show any evidence of illness, another 163 reported proved negative or unconfirmed. Of the remaining 1,343 cases, 797 were limited to eye and skin irritations, which usually responded to treatment without permanent adverse effects. The remaining 546 involved systemic symptoms in which the most serious illnesses lasted less than three days. Chronic problems did not often occur. Dr. Peoples stated that these cases do deserve serious study.

Only 167 of the 1,343 cases involved farm field workers, and only 28 of those involved systemic illness. Upon investigation, 20 percent of the 167 reported cases could not be traced to pesticide exposure. At the same time one should recognize that some cases, no doubt, were never reported.

Blood Cholinesterase Testing

In January and August of 1976, in a special study by the California Department of Food and Agriculture, the blood cholinesterase values of mixer/loaders, mixer/loader/applicators, pilots, and flaggers working in the Imperial Valley of California were determined. In April the blood cholinesterase values of mixer/loaders and mixer/loader/applicators working in Monterey County were determined. The blood values from the Imperial Valley January tests and the Monterey County April tests were analyzed for variance with the values of Sacramento County blood bank donors as controls.

The red cell cholinesterase of mixer/loaders was 20 percent below those of the controls, while the red cell values of mixer/loader/applicators, pilots, and flaggers were reduced to 7 percent, 6 percent, and 1 percent, respectively, below control values. The reduction of cholinesterase was not significant in the cases of pilots and flaggers. The study involved 32 mixer/loaders, 80 mixer/loaders/applicators, 36 pilots, and 40 flaggers.

In the summer of 1977 the blood cholinesterase values of 12 mixer/loaders and mixer/loader/applicators who used closed systems were followed for a period of six months. In previous years, workers at this firm had used handpouring methods and had suffered numerous illnesses; they had experienced consistent and continued cholinesterase depression and were often removed from the job temporarily to allow for recovery of cholinesterase levels. The management had instituted very tight safety regulations that stopped the poisonings that required removal to other jobs but, even then, serious cholinesterase depression continued. After conversion to closed system handling, workers who still handled the same pesticides had cholinesterase values that either increased or remained at the level of the first test, indicating that excess exposure was no longer occurring.

At the very end of the study, two mixer/loaders failed to use closed systems and poured by hand. They suffered a 50-percent reduction in red cell cholinesterase, thus emphasizing the protection afforded them and other workers when closed systems were used.

Regulations Based on Exposure Histories

Since the first emergency worker safety regulations went into effect in January 1974, the intensive study of reported poisonings has continued and revisions have been made in the regulations to make them both practical and effective.

Although too lengthy to cover in detail here, the regulations are brief and to the point compared to the complex safety standards common to OSHA. They bear the same degree of seriousness, however, and are probably more intensively enforced down to the level of the individual farm operator because of California's long history of pesticide enforcement by the County Agricultural Commissioner system.

The California regulations are addressed directly to the areas in which the illness report studies have indicated that injury and illness most often occur. They have the specific purpose of eliminating repeated injuries that are due to the same causes.

Safety of Employed Persons

Below is a brief summary of requirements that must be met for the safety of persons who work directly with pesticides--mixers, loaders, flaggers, and ground or aerial applicators.

1. *Age*. No employer shall permit an employee under the age of 18 to mix or load a pesticide in Category 1 or 2 unless a closed system is used.

2. *Training*. Within 30 days of hire, every employee working with Category 2,3, and 4 pesticides must be trained in safety procedures in handling pesticides. In the case of Category 1 materials, the employee must complete training before beginning work. Training must cover safety procedures, clothing, and equipment. During the training periods the employer must observe the employee at work every hour at night and at least every 2 hours in daylight.

3. *Medical care*. When pesticide work is scheduled, the employer must arrange for emergency medical treatment. He must post the doctor's name, address, and phone number and those of the designated clinic and emergency hospital that will provide care. The employer is required to take suspected cases to a physician immediately.

4. *Medical supervision*. This differs from the medical care noted above and presents an example of preventive care. When an employee's exposure to Category 1 or 2 organophosphate or carbamate pesticide exceeds 30 hours in a 30-day period, the employer must engage the services of a licensed physician to provide medical supervision. Such supervision will involve monitoring the workers by a baseline cholinesterase test before any work and subsequently as recommended by the physician. These requirements require written records and cholinesterase testing procedures to assure adequate protection of workers involved in this sort of high-exposure activity.

5. *Working alone*. Since a poisoned person working alone may not be able to care for himself (and there is a substantial history to confirm this), an employee working alone with Toxicity Category 1 material in daylight must be contacted every 2 hours or less by personnel contact, radio, or telephone by a responsible adult. At night the contacts must be made every hour. Teams such as pilot and his mixer/loader and flagger working together are exempt from this. Two or more ground applicator working in the same field in sight of each other are also exempt.

6. *Clothes changes*. Dermal exposure from pesticide-soaked clothing can be severe, so workers working more than 30 hours in 30 days must be provided with a place to wash and change clothes. Adequate soap, water, and clean towels must be provided. Employers must order their workers to dress in clean clothes each day and to remove those clothes and wash themselves thoroughly at day's end. A clean, pesticide-free place must be provided for storage of street clothes when not in use.

7. *Washing facilities at the worksite*. Clean water, soap, and towels for emergency use must be provided for all employees at the worksite where Toxicity Category 1 and 2 materials are in use. Ten to twenty gallons of water must be provided per worker. More safety details accompany these requirements.

8. *Protective clothing*. Clean outer clothing must be provided by the employer for work with Category 1 and 2 materials. An extra set must be provided, and persons laundering such clothes must be alerted to the potential pesticide contamination.

9. *Safety equipment.* The employer must provide safety equipment and be responsible for cleaning and maintaining it.

10. *Safety procedures.* The employer must advise the employees in correct procedures, as noted on the label, and shall be required to enforce them.

11. *Lighting.* Nighttime operations must be adequately lighted.

Safe Equipment

Means of maintaining the safety of the worker must also consider design and maintenance of pesticide-handling equipment to avoid sources of potential hazard.

1. *Inspection.* Equipment must be inspected periodically to ensure absence of defects. Defective equipment it must be removed from use.

2. *Maintenance.* Persons doing maintenance work on pesticide equipment must be instructed as to the hazards involved and must be provided adequate protective equipment.

3. *Equipment specifications;*
   a. Tank hatches must be leakproof when the vehicle is in motion.
   b. Hoses carrying liquid Toxicity Category 1 and 2 materials shall not pass unshielded through the cockpit of an aircraft.
   c. Hoses used to transfer Categories 1 or 2 pesticides from a mixing tank must have a shut-off device at the exit end or a hose back-flush system so that no pesticide drips when the hose is disconnected.
   d. Tanks of more than 49-gallon capacity for Toxicity Category 1 or 2 materials must have a sight gauge or an automatic filter hose shut-off valve so that the tank will not be overfilled.

4. *Closed mixing systems.* Hand-pouring by employees of all liquid Category 1 pesticides shall be eliminated in all cases after December 31, 1977. The regulations require closed systems during 1977 with a graduated date arrangement and some exceptions. At the present, the employer must arrange for baseline cholinesterase tests of employees working with closed systems for 5 or more days in any consecutive 30-day period. After the first year, one annual cholinesterase determination shall be sufficient if the plasma and red blood cell values are each within 20 percent of the original baseline values. Cholinesterase determination must be in accordance with State Department of Health guidelines. Additional testing is still required for exposures to any organophosphates or carbamate such as liquids in Toxicity Category 2 and dry pesticides of the same types in Toxicity Categories 1 and 2.

Field Worker Safety

Workers who may enter fields that have been sprayed with pesticides are also protected by a series of detailed regulations. Essentially, medical care and hand-washing facilities must be provided, and foremen must be trained to recognize symptoms. No workers may be in a field during pesticide application, and very strict requirements provide for posting with warning signs and with signs indicating that reentry must be delayed at least 24 hours or up to as much as 45 days in one case. Reentry times of 7, 14, 21, and 30 days after chemical application are more common.

Experience So Far

Total banning of hand-pouring of Category 1 liquid pesticides will not become a reality until after December 31, 1977, so firm conclusions about the effectiveness of the closed system requirement must await the experience of future years. Systems have been in use for some years, however, in certain operations.

So far, eight manufacturers have had their systems inspected and approved for commercial distribution. Four systems are being manufactured and sold at the present time. A recent survey of use experience of these four systems has not revealed any operational or safety problems.

Based on a brief survey of the closed systems for liquid pesticide transfers that were coming into use in Calfornia in 1977, the following conclusion can be drawn.

1. The pest control operators are starting to accept the closed system concept of pesticide transfer as an additional tool for efficient use of pesticides rather than a hindrance to their operations that has been forced upon them by the State of California. Partly emptied pesticide containers are not causing the pest control operators the problems they had thought would occur. Employers are finding that proper scheduling of mixing and application minimizes the number of partly emptied pesticide containers and that this same planning increases the efficiency of their entire operation.
2. Employers who require Category 1 liquids for only a very limited portion of their total operations are having that work done by commercial pest control operators who have closed system equipment.
3. Since the regulations apply only to liquids, there is rather extensive work underway to produce dustless dry formulations and soluble bags for dry forms of Category 1 pesticides. Dry materials are not now included in closed system requirements, so reduction of dust in formulations and soluble containers should be of considerable value in eliminating Toxicity Category 1 dry material hazards and at the same time reduce dependence on liquid formulations.
4. The widespread use of the more toxic Category 1 materials is coming under close scrutiny by employers. They are finding in many cases that sufficient control can be obtained by materials not in Toxicity Category 1.
5. During 1976 and 1977 two cases of multiple pesticide illnesses in field worker crews occurred as a result of contact with sprayed foliage. These illnesses, which substantially increased illness totals, were the result of allowing workers to reenter the fields too soon after chemical application, and regulatory action and criminal charges were filed against the employers responsible. Proper adherence to reentry regulations should have prevented these incidents.

Advantages of Closed Systems

The use of closed systems for handling the more toxic agricultural chemicals should have several advantages, including the following:

1. Increased worker safety and improved applicator public image.
2. Use of uncomfortable protective clothing may no longer be necessary.
3. Complex medical supervision may be reduced to a simple initial baseline cholinesterase test.
4. More accurate pesticide measurement will reduce the danger of excess residue or poor results from insufficient application. Reduction of waste of expensive pesticides used in excess may produce substantial cost savings. One applicator reported a 16-percent savings in pesticide costs in one year.

CORN NEMATODES: CHEMICAL CONTROL AND BIOLOGY

D.C. Norton

The importance of nematodes in reducing corn yields in the Midwest is becoming generally recognized. Unlike many pests, nematodes are not seasonal. From the time that the root emerges from the seed, nematodes begin feeding on the roots and continue to do so until the plant dies. Their presence and often the damage caused are insidious. Following are the names of some of the nematodes, along with their common names, referred to in this discussion:

Helicotylenchus--spiral nematodes
Hoplolaimus--lance nematodes
Longidorus--needle nematodes
Pratylenchus--root-lesion nematodes
Tylenchorhynchus, Quinisulcius--stylet or stunt nematodes
Xiphinema--dagger nematodes

Virtually every soil sample from agricultural land contains several genera of plant-parasitic nematodes. Corn is a particularly favorable host, often supporting as many as eight different species in and around its roots in a field. Some nematodes such as *Pratylenchus* spp. are ubiquitous and probably damage corn whereever it is grown. Other nematodes such as *Hoplolaimus galeatus* and *Xiphinema americanum* occur in every state in the Midwest, but may be severe only in certain soil textures and types. Loss can be considerable, however, both to the individual farmer and collectively within a state. Although *Longidorus breviannulatus* is known in only two Midwestern states, evidence indicates that it is one of the most devastating nematodes on corn. Other nematodes such as species of *Helicotylenchus, Quinisulcius,* and *Tylenchorhynchus* are widespread in corn fields, but little is known about their pathogenicity. Some are probably moderately pathogenic, but they can contribute to yield reductions. *Trichodorus christiei,* commonly occurring in sandy soils, was recently associated with severely stunted corn in southern Illinois.

Nematodes have been known to parasitize corn in the Midwest for over a decade, but recently acquired data indicate that nematodes are far more important than previously known. Corn losses due to nematodes are estimated at between 5 and 10 percent for the Corn Belt. Crop losses may be dramatic, sometimes with over 50 percent of a crop lost locally. In most instances, however, losses will be less, but will occur over wide areas. The kinds and amount of nematodes that occur in a given field will be governed by many factors including soil type, climatic conditions, cropping sequence, tillage practices, host susceptibility of the current cultivar, and application of pesticides. Many of the nematicides used are also insecticides. Thus, with continuous corn it is frequently difficult to distinguish the damage caused by rootworms from that caused by nematodes; however, many of our tests in Iowa have been made in fields where rootworm damage was small.

The degree of nematode control by nematicides varies considerably. Combined results for recent years in Iowa are presented in Tables 1 to 5. It should be noted that certain chemicals are more effective against some nematodes than against others. It should be emphasized that the only compound cleared for use against nematodes on corn in the Midwest is carbofuran at 1.5 to 2.0 pounds active ingredient per acre (Furadan 15 to 20 pounds actual product per acre). Most of the compounds used are still experimental. Average yield increases are given in Table 6. The maximum yield increase in any test was 72 percent.

A question frequently asked is, "How many nematodes does it take to cause injury?" The answer is usually difficult because the interactions between environment and nematodes are complex. Populations of *Pratylenchus* spp. over 5,000 per gram of dry root usually cause damage visible to the naked eye, or if the damage is not visible, the farmer suspects that he is not obtaining yields that he thinks the land is capable of producing. Based on data in Iowa, the injury threshold for *P. hexincisus* in corn seems to be from 500 to 1,000 nematodes per gram of dry root over a variety of environmental conditions. Damage at these lower densities usually can be detected by comparing yields with nematode counts in treated and nontreated plots or test strips.

Table 1. Control of Helicotylenchus pseudorobustus in Soil in Corn Plots Treated With Granular Nematicides in Iowa, 1973-1976

Nematicide[a]	Pounds active ingredient per acre	n[b]	Percent control
Temik	3	3	54.8
Temik	2	2	40.2
Mocap	2	7	36.3
Counter	1	4	33.5
Furadan	3	1	29.3
CGA-12223	2	6	29.2
CGA-12223	1	3	28.4
Mocap	1	7	26.6
Furadan	0.75	4	20.6
CGA-12223	1.50	1	19.1
Furadan	4	1	19.0
Furadan	2	13	18.1
CGA-12223	4	1	17.2
CGA-12223	3	6	17.1
Furadan	1	8	13.4
Dasanit	2	5	9.4
Furadan (furrow)	2	2	8.5

[a]Applied in a seven-inch band unless noted otherwise.
[b]Number of tests using compound at specified rate.

Table 2. Control of Pratylenchus spp. in Corn Roots in Plots Treated With Granular Nematicides in Iowa, 1973-1977

Nematicide[a]	Pounds active ingredient per acre	n[b]	Percent control
Vydate (side-dressing)	1	1	95.6
Vydate (side-dressing)	2	1	93.5
Nemacur	4	2	93.2
Vydate + Dyfonate	1 each	1	92.7
Temik	3	3	91.8
CGA-12223	4	2	91.5
Temik	2	3	90.2
Vydate	4	2	89.9
Temik	1	2	86.7
Furadan	3	2	81.4
Counter	1	4	79.2
Vydate	2	2	78.2
Temik	0.75	1	77.6
Vydate	1	2	76.4
Dyfonate	1	1	72.4
Furadan	1.50	8	67.0
Furadan	4	2	65.8
Nem-A-Tak	2	2	62.9
Mocap	3	2	60.0
Mocap	2	8	56.2
Dasanit	2	4	55.2
Furadan (furrow)	2	6	53.2
Furadan	2	20	52.1
Furadan	1	15	46.5
Furadan (furrow)	1	11	40.1
Furadan (furrow)	1.50	11	40.0
Mocap	1	8	35.7
CGA-12223	1	8	29.0
CGA-12223	3	5	25.5
CGA-12223	2	11	25.4
Nem-A-Tak	0.75	2	8.9
CGA-12223	1.50	3	-30.8

[a]Applied in a seven-inch band unless noted otherwise.
[b]Number of tests using compound at specified rate.

Table 3. Control of Hoplolaimus galeatus in Corn Roots in Plots Treated With Granular Nematicides in Iowa, 1973-1976

Nematicide[a]	Pounds active ingredient per acre	n[b]	Percent control
CGA-12223	3	1	81.3
CGA-12223	3.75-4.0	2	76.0
Mocap	1	4	73.1
Mocap	2	4	68.0
CGA-12223	2.0-2.5	3	65.7
CGA-12223	1	5	59.6
Furadan (furrow)	2	1	58.2
Furadan	0.75	3	57.4
Nemacur	4	1	56.3
Furadan	2	8	46.2
Furadan	4	1	45.3
Furadan	1	3	38.7
Furadan	3	1	23.3
Mocap	3	1	22.6
Dasanit	2	4	21.3
Counter	1	3	16.9

[a] Applied in a seven-inch band unless noted otherwise.
[b] Number of tests using compound at specified rate.

Table 4. Control of Tylenchorhynchus nudus in Soil in Corn Plots Treated With Granular Nematicides in Iowa, 1973-1976

Nematicide[a]	Pounds active ingredient per acre	n[b]	Percent control
Temik	2	1	100.0
Temik	3	1	100.0
Nemacur	4	1	93.3
Furadan	4	1	90.0
Furadan	3	2	76.2
Furadan	0.75	2	74.1
Furadan	2	5	70.1
Mocap	3	1	70.0
CGA-12223	2	2	56.7
Mocap	1	3	54.4
Dasanit	2	2	50.0
Furadan	1	3	47.1
Mocap	2	3	42.1
CGA-12223	3	2	21.7
CGA-12223	1	2	18.8
Counter	1	2	10.2

[a] Applied in a seven-inch band.
[b] Number of tests using compound at specified rate.

Table 5. Control of Xiphinema americanum in Soil in Corn Plots Treated With Granular Nematicides in Iowa, 1973-1976

Nematicide[a]	Pounds active ingredient per acre	n[b]	Percent control
Furadan (furrow)	2	1	100.0
Temik	3	2	91.8
Furadan	0.75	2	84.2
Nemacur	4	1	74.3
Temik	2	2	69.6
Furadan	3	1	68.3
Furadan	2	7	67.0
Furadan	1	5	66.9
Mocap	2	3	55.9
Mocap	1	3	55.3
Mocap	3	1	54.3
CGA-12223	3	3	40.3
Dasanit	2	2	28.7
CGA-12223	1.50	1	27.8
CGA-12223	2	5	19.7
CGA-12223	1	3	14.8
Counter	1	2	8.9

[a]Applied in a seven-inch band unless noted otherwise.
[b]Number of tests using compound at specified rate.

Table 6. Average Yield Increases in Corn Plots Treated With Granular Nematicides Compared With Nontreated Plots in Iowa, 1973-1976

Nematicide	Pounds active ingredient per acre	n[a]	Pct. yield increase[b]
Counter	1	4	19.9
Temik	3	2	17.2
Mocap	2	7	17.1
CGA-12223	1.50	1	16.9
Temik	2	2	15.1
Dasanit	2	6	15.1
Furadan	2	16	14.7
CGA-12223	3	7	13.7
CGA-12223	2.0-2.5	8	12.6
Mocap	1	7	12.0
Mocap	3	1	11.4
Nemacur	4	1	9.5
CGA-12223	3.75-4.0	3	9.4
Furadan	0.75-1.0	13	8.2
Furadan	4	2	6.3
Furadan (furrow)	2	3	3.9
Furadan	3	2	2.8
CGA-12223	1.0-1.25	6	1.8

[a]Number of tests using compound at specified rate.
[b]Based on combined yields in all tests.

INCORPORATION OF HERBICIDES IN REDUCED TILLAGE SYSTEMS

B.J. Butler, L.E. Bode, L.M. Wax

Many farmers are switching to a reduced tillage system in their corn and soybean production program. Advantages in changing to a reduced tillage system include soil conservation, reduced energy concerns, earlier planting dates, and fewer problems with unavailability of suitable labor. However, farmers using reduced or no-till practices have reported a reduction of seed germination; increased weed, insect, and disease pressures; and inconsistency in obtaining optimum yields.

Weed control programs for corn and soybeans have relied increasingly on preplant incorporated herbicides. Many of these herbicides have proven reliable in many soil types under a variety of climatic conditions. The commonly accepted incorporation pratice is to apply the herbicide to a well-tilled seed bed and mix the chemical in the soil with two perpendicular passes with a tandem disk or field cultivator. Some farmers have tried the reduced tillage practice of applying a herbicide to rough chiseled ground and incorporating with a single pass using a tandem disk or field cultivator. In some cases this practice has resulted in decreased weed control. Evidence indicates that the effectiveness of incorporated herbicides is partly determined by the uniformity and depth of incorporation. Studies were conducted at the University of Illinois to evaluate the soil incorporation characteristics of two sizes of tandem disk harrows, a field cultivator, a Lely Roterra, and a Forrest City Do-All.

Results of both field and laboratory studies verify that two passes with disks or field cultivators are required for adequate incorporation. A single pass results in areas of high chemical concentrations where crop damage can occur, and areas of low or no concentration where weed streaking can occur. Two passes are required to improve incorporation uniformity, but our tests indicate that the second pass can be parallel, perpendicular, or at any angle with the first with very little loss of mixing uniformity. Timing of the second pass generally is also not critical. If the herbicide is sufficiently covered on the first incorporation pass, the second pass can be delayed until the final seedbed preparation just before planting.

Travel speed and operating depth have the greatest effect on vertical placement of herbicides incorporated with both large and small disks. With increases in travel speed, the chemical is generally incorporated to a shallower depth. Increases in operating depth increase the depth of incorporation. In general, the peak concentration of chemical is at one-half to two-thirds of the operating depth of the disks. One exception is large disks operated at shallow depths. At a depth of less than 4 inches the disk blades inadequately invert the soil, resulting in very little soil mixing. When operated at depths of 6 inches or more to invert the soil, the blades incorporate some of the herbicide deeper than desired. Thus, large disks incorporate best at a 4- to 6-inch depth. There is also some loss of horizontal uniformity when incorporating with large disks. Spacing of disk blades and depth of operation seems to be more important than blade diameter in determining the amount of soil mixing.

Two passes are required to obtain adequate incorporation with the field cultivator. Best results are obtained when the field cultivator is operated at a shallow depth and at a speed of 5 to 7 miles per hour. To avoid areas of low chemical concentration resulting in strips of weeds, the second pass should be angled across the first pass rather than parallel to it. If the rear row of shanks is allowed to operate deeper than the forward rows, untreated soil may be brought to the surface, resulting in reduced weed control. A light drag or harrow should be mounted behind the cultivator to level the ridges and give a light mixing.

Vertical distribution of chemicals from the Do-All and Rottera is affected mainly by operating depth. Placement of chemicals with both these tools is much shallower than with the disks.

Peak concentration of granules for the Do-All is in the top two inches of soil regardless of travel speed or operating depth. The ground-driven reel on the Do-All has very little effect on vertical placement of the herbicide, but does result in as good a horizontal distribution as can be obtained in two passes with the disks. Under good soil conditions a single pass with the Do-All will give adequate soil incorporation for most herbicides.

A single pass with the Roterra gives a uniform shallow mixing of material. There is very little vertical soil mixing with the Roterra, with most of the chemical remaining in the top 2 inches when operating to 5-inch depths. Overall, a single incorporation pass with the Roterra provided the most uniform horizontal distribution of the implements tested.

In summary, the type of herbicide incorporation used must be a part of the tillage and planting system. Although two passes with a tandem disk or field cultivator are required to give fairly uniform mixing of herbicides in the soil, this method may result in more trips through the field than are required for a conservation tillage program. If a tillage system does not allow two passes with disks or field cultivators, or one pass with each to incorporate a herbicide, then an alternative weed control program should be considered. One possible alternate system is to apply the herbicides between the front and rear gangs of a tandem disk, and then to make a single incorporation pass. Sufficient research data confirming the effectiveness of this system is not yet available; nevertheless, this method would probably give adequate weed control where soil tilth is good. Although some tillage tools, such as the Do-All and Roterra, have potential for one-pass incorporation treatments, they do not incorporate chemicals as deeply as tandem disks and may not give adequate control of deep-seeded weed seeds such as nutsedge, quackgrass, and johnsongrass. For shallow germinating weed seeds, single pass incorporation is adequate for most herbicides. In some cases, power-driven tools are mounted directly ahead of the planter to level the soil, incorporate the herbicide, and prepare a smooth seedbed for planting in a single pass. This procedure, however, is not suitable for all soil types and farming practices.

WEED CONTROL FOR SOYBEANS IN 1978[1]

L.M. Wax

Most Illinois soybean acreage is treated with one or more herbicide applications for weed control. These herbicide treatments are generally very effective on annual grasses and on some broadleaf weeds. They have played a large role in reducing losses due to weeds in soybeans; when combined with cultural and mechanical means of control, they provide relatively consistent and selective control.

However, the results obtained with herbicides do vary somewhat from season to season and under different environments. The 1977 cropping season in Illinois seemed to be characterized by extremes in weather patterns, and partly because of this, several problems developed with regard to herbicide usage. Three particular problems were most apparent and will be mentioned here.

One of the most obvious problems was simply the failure of many preemergence treatments to provide satisfactory control of either grass or broadleaf weeds because of dry weather following planting and herbicide application. This problem is certainly not a new one; producers have come to expect such adverse weather patterns perhaps one year out of every three or four. For some, however, 1977 was the second or third consecutive year of such unfavorable conditions. For these producers, a change for 1978 may seem in order.

Some options are probably obvious but will be mentioned here. First, in the long run, rainfall patterns will probably average out so that preemergence treatments *will* be effective in three out of four years, if the producer will stay with his preemergence program. Second, in the event of dry weather, weed emergence and growth are usually reduced, and rotary hoeing and cultivation can be quite effective in controlling weeds. The third option would be the use of a preplant soil-incorporated herbicide treatment. Several herbicides are available for this type of application and are usually less dependent on weather for satisfactory weed control.

Another problem in 1977 (and in most other years as well) was the erratic control of some of the large-seeded broadleaf weeds, even under optimum moisture conditions. Such weeds as velvetleaf, jimsonweed, morningglory, cocklebur, and giant ragweed may germinate over a long period, emerge from deep in the soil, or just be physiologically resistant to the particular herbicide in use. As a result, they frequently are not controlled adequately. The solution to this problem lies in mapping weed species on farms and selecting herbicides with the best chance of controlling the predominant species. Combinations of herbicides, as tank mixes and as sequential applications, also help control these species.

[1]This is a report on the current status of research involving use of certain chemicals that require registration under the Federal Insecticide, Fungicide, and Rodenticide Act, as amended by the Federal Environmental Pesticide Control Act. It does not contain recommendations for the use of such chemicals, nor does it imply that the uses discussed have been registered. All uses of these chemicals must be registered by the appropriate state and federal agencies before they can be recommended.

The other major problem encountered in 1977 concerned injury to soybeans. Injury to young soybeans by triazine herbicides was fairly widespread in soybeans in Illinois. Many fields showed evidence of injury to soybeans where metribuzin (Sencor, Lexone) was used. Injury was perhaps greatest where atrazine-treated corn had been grown in 1976, followed by metribuzin-treated soybeans in 1977. However, there were numerous instances of injury to metribuzin-treated soybeans that did not follow atrazine-treated corn. Injury to soybeans not treated with metribuzin was fairly common from residues of atrazine.

Although these injury problems appeared fairly serious early in the season, many were greatly diminished as the season progressed and soybeans overcame this early injury. Most of the situations where injury remained severe could be attributed to overlapping, soil differences, or misapplication.

Some of these injury problems can be at least partially explained by the nature of the herbicides and the weather. Metribuzin, although it is an excellent herbicide for weed control in soybeans, does not have a large margin of safety with regard to soybeans and sometimes causes soybean injury. Usually, soybeans recover with no yield reduction. But reduction of rate is not the answer—the completely "safe" rate will fail to control weeds in some years.

Occasional injury to soybeans from residual atrazine has occurred for many years. Most of the time the injury is only in localized spots in a field, and even there it is due to soil differences or misapplication. However, the factors that reduce atrazine breakdown (dry and cool weather) and thus tend to create residue problems have occurred over the past two years. The trend toward decreased tillage also tends to cause more residue problems. Thus the increase in residue problems should not be completely unexpected.

Where an injury problem can exist with either directly applied metribuzin alone or atrazine residue alone, it seems reasonable to assume that the two problems might be additive and cause a problem more often when combined. Field results seem to verify this. But even then, in most instances injury is temporary where both materials were used according to the label.

The solution to these problems for the future would seem to be selecting and using correct rates of metribuzin for the soil type, using atrazine only in combination at reduced rates where soybeans will follow corn, using tillage (perhaps moldboard plowing) following atrazine-treated corn, and perhaps using an alternative treatment for either atrazine or metribuzin. For much of the area, increased rainfall in late summer and fall has probably done much to decrease the chance of residue problems from atrazine next spring and summer.

Following is a discussion of the herbicides and cultural practices that will likely result in better weed control in soybeans. Some herbicides are on the market, some are nearing registration, and some are very new materials that show considerable potential but require more evaluation. Herbicide uses are discussed both according to time of application (preplanting, preemergence, and postemergence) and in fairly general terms. Specific recommendations are found elsewhere in this manual in the "1978 Field Crops Weed Control Guide."

Preplant incorporated herbicides are widely used for weed control. Trifluralin (Treflan) is the most widely used preplant herbicide in soybeans; in some areas, substantial acreage is treated with vernolate (Vernam). Both of these herbicides provide good control of annual grasses but seldom control many other species. Vernolate, however, is effective for control of yellow nutsedge. Several other herbicides that are chemically similar to trifluralin (dinitroanilines) have become available and are labeled for use in soybeans, either singly or in various combinations. This group of dinitroanilines includes such herbicides as fluchloralin (Basalin), dinitramine (Cobex), pendimethalin (Prowl), and profluralin (Tolban). In general, these herbicides provide about the same kind of weed control that trifluralin does. There are some differences in residual activity within the group, with dinitramine having the shortest soil life. Some of the herbicides, such as dinitramine and pendimethalin, may provide slightly better control of certain annual broadleaf weeds than trifluralin does; however, this slight increase in control usually does not adequately control broadleaf weeds, for which other herbicides are needed.

Preemergence applications of herbicides also are used widely for weed control in soybeans. Chloramben (Amiben), alachlor (Lasso), linuron (Lorox), and combinations of alachlor plus linuron have been used most widely. Alachlor plus linuron has been especially effective on medium-textured soils with 3 percent or less organic matter, where it provides fairly broad spectrum weed control. Alachlor is effective for control of yellow nutsedge, but it is more effective when soil-incorporated than when applied preemergence.

Metribuzin (Lexone, Sencor) is one of the most effective (and most widely used) herbicides for improving annual broadleaf weed control in soybeans. Metribuzin controls a broad spectrum of weeds, but it sometimes injures soybeans, as mentioned previously. As with other herbicides applied preemergence, metribuzin depends on rainfall within a few days after application for optimum effectiveness. Incorporation into the soil reduces this dependence on rainfall to some extent, but it may also increase crop injury slightly. Most common soybean varieties seem to have fair tolerance and only minor variation in response to metribuzin. However, several varieties in the USDA soybean germplasm collection are often severely injured or killed at metribuzin rates roughly double those recommended. Because soybeans are not very tolerant of metribuzin, special care is required in selection of rates and application procedures. Our most promising results with metribuzin have come from combinations of metribuzin plus various dinitroanilines (both incorporated preplant), metribuzin applied to the soil surface preemergence as a sequential treatment after one of these dinitroanilines, or a preemergence application of metribuzin with alachlor.

Several new herbicides that are chemically very similar to alachlor are in various stages of evaluation. In general, they perform very much as alachlor does, both in regard to crop tolerance and degree of weed control. One of these, metolachlor (Dual) is slightly more persistent than alachlor and provides slightly better control of nutsedge than alachlor does. Metolachlor is not, however, labeled for use in soybeans yet.

Oryzalin (Surflan) is a herbicide for preemergence use on soils with less than 3 percent organic matter. It primarily controls annual grasses but is cleared for mixing with linuron, metribuzin, or naptalam-dinoseb for improving broadleaf weed control. If 1/2 inch of rain does not fall within seven days after application, you should rotary hoe to control emerging weeds.

Postemergence treatments may help to control broadleaf weeds that escape earlier control measures. Although widely used in the South, postemergence treatments have been used on only a very small part of the soybean acreage in Illinois. For various reasons, the available treatments have not been accepted widely; however, postemergence treatments do offer the grower another set of options for controlling escaped broadleaf weeds. These treatments, when properly selected and applied, may be superior to treatments applied preplant or preemergence. Different treatments may be of value for application at the following stages of soybeans: ground cracking or emergence stage—dinoseb (Premerge) or dinoseb plus naptalam (Dyanap); early postemergence over the tops of soybeans and weeds—chloroxuron (Tenoran), bentazon (Basagran), or dinoseb plus naptalam; directed applications to the base of soybean plants—dinoseb, 2,4-DB, linuron, or paraquat; over-the-top applications at soybean blooming—2,4-DB; and preharvest application to desiccate weeds when soybeans are essentially mature—paraquat.

Bentazon is one of the newest and most widely used postemergence treatments. Applied over the tops of young, actively growing soybeans and weeds, bentazon control weeds such as cocklebur, jimsonweed, smartweed, and velvetleaf, while causing little or no injury to our common soybean varieties. Bentazon is also effective against Canada thistle and yellow nutsedge. It does not control annual grasses and is often erratic in control of annual morningglories and pigweeds. Results with bentazon, especially on velvetleaf, are much better if it is applied when the velvetleaf is very small (less than 2 inches tall). The most effective use of this compound has been as a sequential treatment after other herbicide treatments used earlier for grass or broad-spectrum weed control.

Perennial grasses, such as johnsongrass and quackgrass, infest soybeans in southern and northern Illinois, respectively. Recent developments in herbicidal treatments allow for better control of johnsongrass, and other treatments show much promise for control of both johnsongrass and quackgrass. Glyphosate (Roundup) is a new herbicide that, when applied to the foliage of these grasses, translocates throughout the plant shoots and roots and provides excellent control. It has considerable potential for use on these species before soybeans are planted in the spring or perhaps in the fall following a small grain crop. Soybeans are not sufficiently tolerant of glyphosate, however, to allow its use as a broadcast treatment over soybeans and weeds.

A recirculating sprayer has been developed that allows the use of herbicides such as glyphosate over the tops of soybeans, spraying only the weeds that extend above the soybeans; the weeds are controlled with little or no injury to the soybeans. Glyphosate also shows considerable promise in combinations (several are registered) for use in double-crop soybeans planted in stubble following small grain harvest.

Various other herbicides, still being evaluated, have considerable potential for selective control of volunteer corn and both annual and perennial grasses in soybeans, when applied over the tops of young soybeans and weeds. These and other new herbicides and application techniques would indicate increased success with weed control in soybeans in the years ahead.

TURFGRASS INSECT MANAGEMENT

Roscoe Randell

The control of insects in turfgrass has been improving rapidly during the past ten years. Custom applicators, commonly known as lawn care companies, are offering their services to homeowners, and insect control has become an integral part of this expanding business. Insecticides used on turfgrass today are less persistent than the chlorinated hydrocarbons, chlordane and dieldrin, commonly used ten or more years ago. This report will discuss some of the changes in the lawn care industry and in the use of insecticides, and their effects on turfgrass insect management for today and the near future.

Lawn Care Industry

An excellent summary of lawn care companies and the services they provided was reported in the March 1977 issue of "Weeds, Trees, and Turf." Dr. Robert W. Miller, vice president of ChemLawn Corporation, stated in the article that lawn care companies range from mowing services to those that specialize only in pest control to franchised companies offering a wide range of services. Some lawn care companies have begun to operate in several cities on a regional or national level. Millard C. Dailey is president of Liqui-Green, a lawn care business started 20 years ago in Peoria, but now franchised in Illinois, Iowa, and Pennsylvania. He began by fertilizing lawns, then added weed control, and finally insect and disease control. Mr. Dailey stated that, for the industry to continue to grow, the companies must employ professionals and offer a wide variety of services to the homeowner. But Dr. Miller feels that the industry is unorganized at the present time and has no uniform standards of quality.

In Illinois custom lawn care applicators apply insecticides to home lawns and other turfgrass areas. For example, ChemLawn, Liqui-Green, and other large and small companies provide chemical insect control to many lawns in Illinois. The number of lawn care companies and lawns treated will continue to expand. Services will also expand to include larger turfgrass areas such as parks, industrial sites, and even golf courses. The future success of these companies will depend on the level of company personnel training on up-to-date pest control and application methods.

1977 Turfgrass Insect Problems

Circular 1073, "Turfgrass Pest Control," found elsewhere in this manual, lists the 1978 control suggestions for specific insect problems. The following section summarizes some of the major insect problems that appeared in 1977 and the results of applied insect control.

Annual white grubs. This insect attacked the roots of bluegrass in many home lawns, parks, and golf courses across the central part of the state in late August and September. The number of grubs ranged from 8 to 30 or more per square foot. The labeled insecticides that were effective included diazinon and trichlorfon (Dylox or Proxol). Experimental insecticides that were effective included Ficam and CGA-12223. Both the granular and the liquid concentrate were effective if the turfgrass area was irrigated immediately after application until the grub-infested area was wet. *Ataenium spretulus*, the small grub attacking the roots of bentgrass, was observed in some areas, but the number of reported grubs was low. There were many reports from other states, especially Kansas.

Sod webworms. The lawn webworm, *Cranulus trisectus*, damaged many well-kept lawns over much of Illinois. There was first generation damage in the northern part of the state and earlier than usual second generation damage in early July in many areas of the state. Sevin, diazinon, Aspon, and Dursban applied as granules or spray to the grass foliage gave good control. The bluegrass webworm, *C. teterrellus*, was found in high numbers and severely damaged bentgrass golf greens in the western part of the state. Diazinon and Dursban were both effective for emergency control of this uncommon insect.

Greenbugs. These small green aphids sucked plant juices from bluegrass leaves growing under trees. The damaged areas, which were brown or reddish-brown, appeared below the tree drip line. The aphids feed on the outer edge of the damage area.

Chinch bugs. This insect appeared in either bluegrass or bentgrass patches in bluegrass lawns. The damage appears in the sunny areas of the infested lawn.

Cutworms. This insect, especially the black cutworm, damages golf greens. The damage this year was moderate from May through August on untreated greens. In insecticide trials Dursban gave good control. Initial applications of trichlorfon were effective, but unlike Dursban, had little residual activity. Experimental insecticides were applied in 1977 with the synthetic pyrethroid Pounce, which gave good control.

Emergency treatment for controlling turfgrass insects has changed. Instead of applying an insecticide with long residual life, a less persistent chemical is now applied when the problem is first detected. There are now effective insecticides for the problem insects. Whether the turfgrass insect problem is taken care of by the lawn owner or a lawn care service, good control is the result of correctly identifying the problem, assessing the potential for damage, and if necessary, using an effective chemical for control.

EFFECT OF SOIL AND WEATHER FACTORS ON HERBICIDES

V.M. Jennings

An area of concern to some crop producers is the effect of herbicide application and carryover on their crops. Most of this concern recently has centered on triazine injury to soybeans--occasionally to corn--and dinitroaniline carryover onto corn from previously treated soybean fields.

Triazine Injury to Soybeans

Triazine injury to soybeans results from two commonly used herbicides, atrazine and metribuzin (Lexone and Sencor). The injury caused by atrazine results from applications made to the corn crop the previous year, while injury caused by metribuzin results from direct application on soybeans.

Both herbicides are photosynthetic inhibitors. Injury occurs through root uptake by the soybean plant. When the herbicide reaches the leaves of the soybean plant, photosynthesis is inhibited and the lower leaves turn bronze (chlorosis), then die (necrosis). If herbicide uptake is sufficient, the injury will move up the plant and may cause the plant to die. This will result in stand reduction. Injury symptoms for atrazine and metribuzin damage are the same. Therefore, if atrazine was applied to corn the previous year and metribuzin is applied in the same field to soybeans this year, it may be impossible to determine which chemical is causing the injury. Since they both affect the plant the same way, a combination of the two chemicals may have an additive effect (Fig. 1).

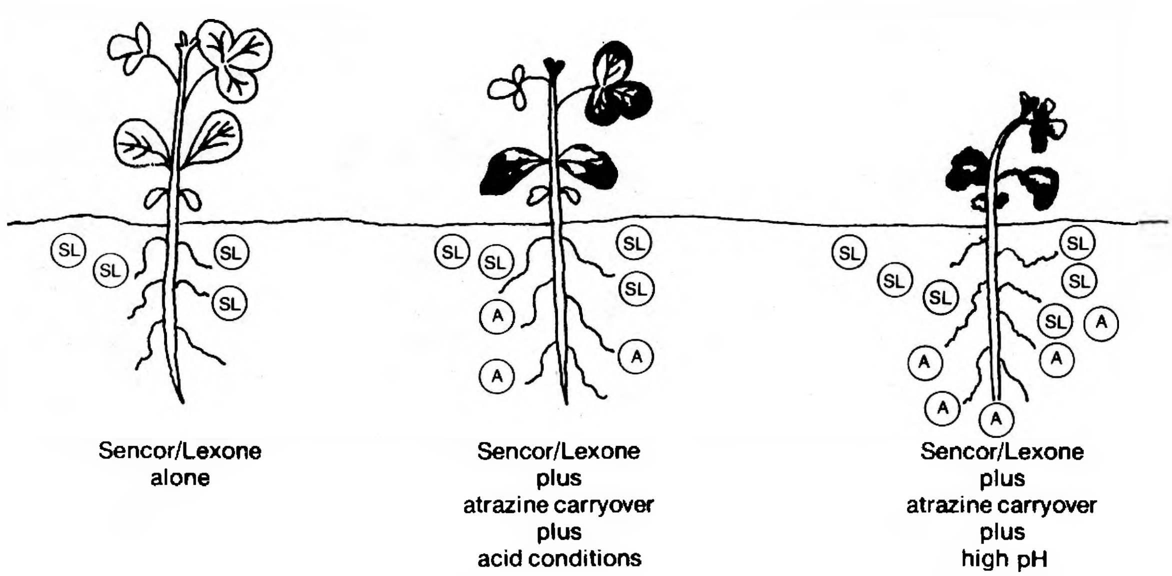


Figure 1. The additive effect of carryover atrazine to Sencor/Lexone when used alone and in combination on soybeans under acid and high-pH conditions.

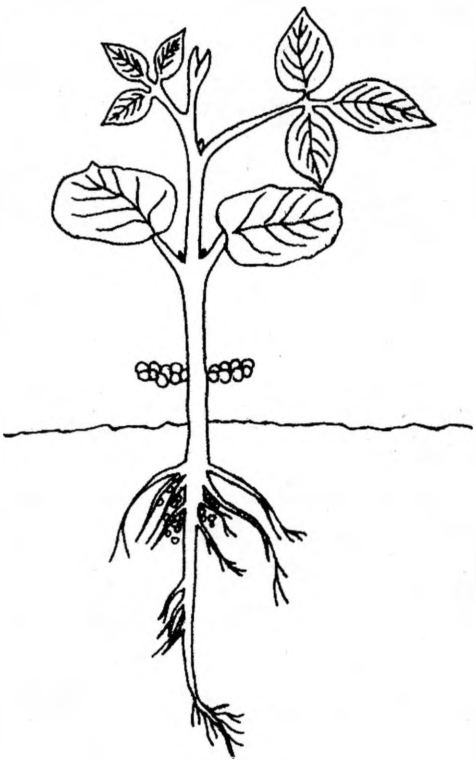


Fig. 2. Parts of a young soybean plant.

Yellowing of soybean plants caused by triazine injury is often confused with iron-deficiency chlorosis, which is common on high-pH soils in the Clarion-Nicollet-Webster soil association in north-central Iowa. Chlorosis caused by iron deficiency is different from that caused by triazine injury. Iron-deficiency chlorosis will occur first on the newly emerging or upper leaves of the soybean plant (see Fig. 2 for plant structure). The lower leaves will remain dark green. The portion of the leaf between the veins will be very yellow in sharp contrast to the veins, which will remain green. Triazine chlorosis, however, occurs first on the older, lower leaves of the plant. Many of the lower leaves may have died and fallen off the plant. The leaves just above will be yellowing and turning brown, and newly emerged leaves on the top of the plant may still be green.

Soil pH

Triazine injury and iron-deficiency chlorosis are often confused in north-central Iowa since both occur on high-pH soil types. This should not be a problem with most soils in Illinois.

Several researchers have shown that atrazine breaks down more slowly in a high-pH environment. The data in Table 1 are from an experiment conducted at the Iowa State University Agronomy-Ag Engineering research center. The experiment was started in the fall of 1966 to determine the effect of limestone application and soil pH on corn yields. Rates of up to 32,000 pounds of effective calcium carbonate equivalent (ECCE) per acre were applied to the field, and the soil pH was raised from 6.04 to 7.63 where the high rate was applied.

Corn was planted in the field for the last time in 1973 and 2 pounds per acre of atrazine 80W were applied preemergence to the corn. After this experiment was terminated, bulk soybeans were planted in the plot in 1974 and 3 quarts per acre of Lasso were applied. In early July 1974, triazine injury was observed in the soybeans; the injury was more severe in some plots. The plots were rated for injury on July 10, 1974 (Table 1).

Injury to the soybeans increased with higher soil pH. A soil pH above 7.3 caused severe reductions in growth and stand and severely reduced yields. These data substantiate what is commonly observed on naturally occurring high-pH soils in Iowa.

When the field was planted to soybeans again in 1975, no injury was observed.

High-pH soils may also be a problem along limestone rock roads. Dr. Gerald Gogan, extension crop production specialist at Cedar Rapids, sampled several fields to determine soil pH at varying distances from a road. Table 2 shows the soil pH in three fields sampled. Areas from 100 to 200 feet from a limestone rock road had a high pH. This explains why triazine injury may be more severe near field edges.

Table 1. Effect of Soil pH on Soybean Yields and Injury Due to Atrazine Carryover (two pounds of atrazine 80W applied preemergence to corn in 1973)

Lime treatment pounds ECCE[a]	Soil pH at 0 to 6 inches	Visual injury rating[b]	1974 soybean yields, bu./A.
0	6.04	1.17	47.9
1,000	6.10	1.00	48.8
2,000	6.22	1.17	50.3
4,000	6.47	2.33	45.2
8,000	7.02	2.17	44.4
16,000	7.27	3.33	36.4
24,000	7.33	4.17	19.3
32,000	7.63	4.33	17.5

[a]Lime applied in fall 1966.
[b]July 1974 visual injury rating: 1 = normal; 2 = slight growth depression; 3 to 4 = moderate growth depression and some stand reduction; 5 = severe growth depression and stand reduction.

Table 2. Effect of Distance from Limestone Rock Road on Soil pH in Three Linn County, Iowa, Fields

Distance from road center (feet)	Soil pH Field 1	Soil pH Field 2	Soil pH Field 3
50	7.7	7.8	8.0
100	7.3	8.0	---
150	7.0	7.8	---
200	6.7	7.4	---
300	6.7	7.0	---
500	6.3	6.8	---
700	6.5	6.6	6.4

The actual pH along limestone rock roads can be determined only by a soil test. It is normally recommended that soil samples not be taken in the fields next to limestone rock roads. If a farmer is using triazine herbicides or planning to apply limestone, he should first sample a strip 50 to 100 feet wide next to the road to determine the pH. Farmers with high-pH soils should be aware of these areas and manage their herbicide use to prevent crop injury.

Proper attention to the herbicide label will help avoid problems. The label for the Sencor brand of metribuzin has the following statement: "*Injury may occur to soybeans following the application of Sencor 50% wettable powder on soils having a calcareous surface area or a pH of 7.5 or higher.*" The label for Lexone brand of metribuzin states: "*Do not use on soil above pH 7.4.*"

Soil Organic Matter and Texture

Herbicide rate recommendations often vary according to organic matter and soil texture. Metribuzin is quite responsive to changes in organic matter and soil texture;

therefore, it needs to be adjusted carefully to these soil variables and pH to achieve maximum weed control and to avoid crop injury. Both the Lexone and Sencor labels specify not to use that herbicide on sands, regardless of their organic matter level, or on loamy sands or sandy loams with less than 2 percent organic matter. The Lexone label also indicates that it should not be used on any soils that have less than 0.5 percent organic matter.

Organic matter and soil texture contribute to the exchange complex of a soil. The higher the organic matter and the finer the soil (higher clay content), the higher the exchange complex. Triazine herbicides are adsorbed by soil colloids (organic matter and clay). Many tirazines, such as atrazine and metribuzin, break down by chemical hydrolysis. Higher organic matter content and finer texture allow greater adsorption of the herbicide, leaving less herbicide in the soil solution available for uptake by the plant under acid conditions.

As shown in Figure 3, atrazine is tightly adsorbed by the clay in the soil. High levels of soil moisture must be present in combination with atrazine adsorbed to the clay for hydrolysis to occur. Breakdown of atrazine is most rapid under these conditions, and carryover is least likely to occur.

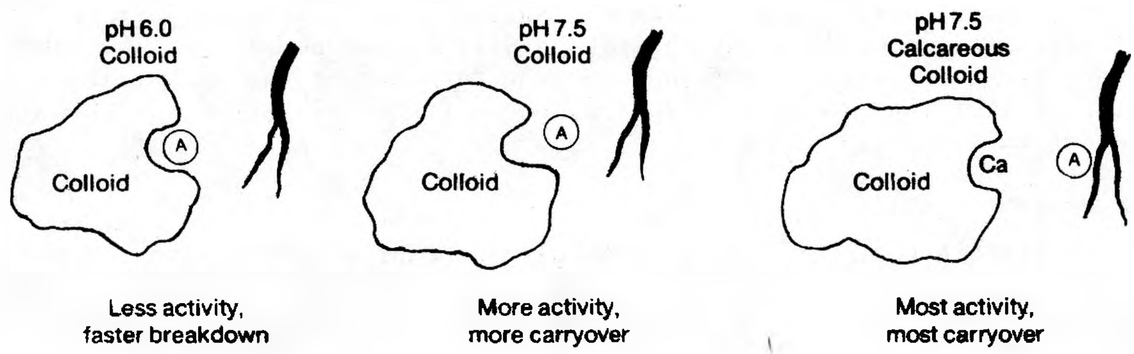


Fig. 3. Atrazine activity and carryover as affected by pH.

As soil pH increases (Fig. 3), atrazine becomes less polar, losing some of its affinity for the negatively charged clay particles. When this association is lost, breakdown of atrazine is slower and the potential for carryover is increased. This problem becomes more complex in calcareous high-pH soils because calcium occupies many of the exchange sites on the clay particle; the breakdown of atrazine is greatly reduced and the potential for carryover is greatest. The same situation may account for increased activity of metribuzin on high-pH soils.

Although not mentioned in Table 1, the experiment reported there also showed a pronounced difference in atrazine injury due to organic matter. Organic matter varied from one side of the plot to the other. Atrazine injury was visually more severe and yield reduction was greater on the plot areas that were lower in organic matter.

Many herbicides other than triazines are sensitive to organic matter levels. If a herbicide is sensitive to organic matter levels and soil texture, the label will show recommended rates for each combination. Soil analysis to determine organic matter levels in each area of the field is a must for proper herbicide application.

Misapplication

Improper application due to faulty equipment, poor calibration, or mistakes can often be identified as the reason for triazine injury. There is a delicate balance between adequate weed control and crop injury. With atrazine, the damage from overapplication may not be evident until a different crop is planted in the field the next year. With metribuzin, the effect will show up in the soybeans during the year of application.

To insure proper application, good equipment must be used. A worn nozzle may deliver a higher rate of spray than a new nozzle. Nozzles should be checked for uniform application rate before calibrating the sprayer. Accurate calibration is a must for applying any herbicide. Spray charts that give delivery rates for a given pressure, speed, and nozzle size are a good place to start your calibration. They are not accurate enough, however, to determine your final mixing rate. The sprayer should be calibrated in the field at the speed and pressure you will use during application. If you must change the speed or pressure, it will be necessary to recalibrate.

In the field the operator must be sure not to overlap the spray boom. This can lead to double application and almost certain injury.

Most triazine herbicides require agitation in the tank to keep the herbicide in suspension. Failure to provide proper agitation will cause the material to settle, and most of the herbicide will be removed from the tank during the early spraying of each fill. If it is necessary to stop and shut off the sprayer, allow time for proper mixing after restarting.

Soil and Weather Conditions

Injury from atrazine carryover is more likely to occur after a season in which rainfall after the herbicide application was below normal. Plowing the field before planting next year's crop will mix atrazine with the soil, which will dilute herbicide concentration and reduce the possibility of injury. When applied at equal rates, preplant or preemergence applications will have less residue than postemergence applications. If atrazine is applied after June 10, do not rotate with crops other than corn or sorghum the next year.

Metribuzin herbicide is highly water soluble (1,200 ppm at 20° to 27° C). Heavy rainfall following preemergence application, particularly on poorly prepared seedbeds, can quickly move metribuzin into the soybean root zone and injure the plants. This can happen on almost any soil type. Planting soybeans at least 1.5 inches deep will help minimize this problem. Usually, this injury is not as severe as first observations would indicate, and only the lower, older leaves are affected. Often, there is no stand reduction and no reduction in yield.

Injury from metribuzin on soybeans and cyanazine (Bladex) on corn often follows a period of cool, wet weather. If the triazine is taken up by the root system during this period, the enzyme system within the plant may not be able to detoxify the chemical. If, following this period, warm, sunny conditions occur and persist, rapid chlorosis and injury to the crop may occur.

Triazine Injury on Corn

There appears to be no risk of corn injury when using atrazine as a preplant incorporated or preemergence treatment. Injury ranging from temporary stunting and marginal leaf burn to actual corn kill can occasionally occur with atrazine plus oil postemergence application. Any factor that puts the corn plant under stress, such as cold wet weather, increases the chances for injury. Risk of corn injury also increases as the rate of postemergence atrazine is increased. Risk of injury is minimized if all label precautions are followed.

Corn injury in the form of yellowing and leaf burn beginning at the tips can sometimes occur from cyanazine (Bladex) herbicide if the rate is too high for the soil type or if heavy rains carry concentrated amounts into the root zone. Bladex is strongly affected by soil organic matter and texture; because rates must be adjusted accurately for soil type, Bladex is not well suited for variable soils. Corn injury can sometimes occur where soils are lighter and lower in organic matter than the soils elsewhere in the field that were used to determine the rate of Bladex application.

Temporary yellowing and burn of corn leaves occur more often with postemergence Bladex treatments than with comparable atrazine plus oil treatments. Do not apply Bladex when the fifth leaf of corn is visible. Surfactants may be warranted when applying Bladex postemergence in drouthy conditions, but they may increase the risk of crop injury. Do not apply Bladex postemergence with liquid fertilizer or petroleum crop oils because serious injury can result. Bladex does not leave a soil residue which might injure crops the year following application.

Dinitroaniline Herbicide Effects on Corn

Dinitroaniline herbicides are soil-applied chemicals absorbed mainly by shoots and to some extent by roots. Very little chemical movement occurs within the plant, so the primary effect of the herbicide is on the roots. Cell division and lateral root formation are inhibited. Corn injured by carryover of dinitroaniline herbicides will show root pruning with short, thick roots (Fig. 4). Root tips will be enlarged. Leaf tissue on injured plants may have a purplish cast. This discoloration is an expression of anthocyanin, a plant pigment, and indicates an accumulation of sugars in the leaves. This means there is limited translocation of sugars to the roots.

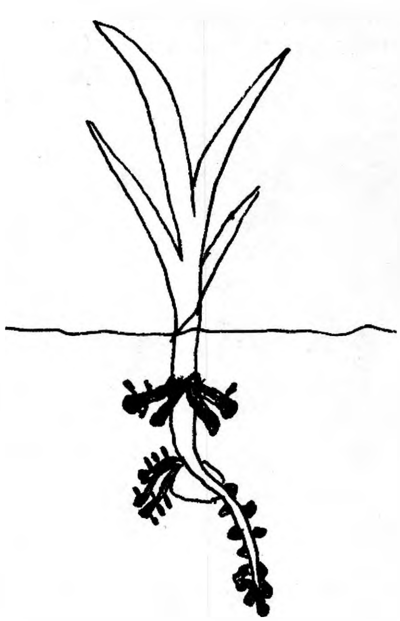


Figure 4. Effect of a dinitroaniline herbicide on the root system of corn. Root growth is inhibited and root tips are swollen. Plants appear stunted and leaves may have a purplish discoloration.

Dinitroaniline herbicide injury on corn has been a problem the past few years in the Corn Belt. It has usually centered around carryover of trifluralin (Treflan) mainly because of the large use of that herbicide on soybeans. Persistence studies would indicate that similar problems could exist where other dinitroaniline herbicides, like profluralin (Tolban) and pendimethalin (Prowl), were used at rates that provided equivalent weed control.

It is not as likely that carryover of dinitramine (Cobex) and fluchloralin (Basalin) would occur.

If pendimethalin (Prowl) is misapplied to corn so that it is concentrated near the primary or permanent root system at the time of early root development, then these roots will be inhibited and the plants stunted also. This would occur if Prowl were applied as preplant incorporated instead of preemergence. In Iowa it has also occured where corn was planted shallow in a depression left by the planter press wheel and Prowl-treated soil was then dragged into the depression by a spike-tooth harrow.

Environmental Conditions

The incidence of dinitroaniline carryover is a function of precipitation and soil moisture levels. If drought conditions persist after application, the herbicide will not break down rapidly in the soil; since it is not water soluble and is tightly adsorbed, it will remain where it was applied. In years of normal or above normal precipitation, you would expect few dinitroaniline carryover problems.

Effect of Methods of Application and Tillage

Since most dinitroaniline soybean herbicides are nonmobile in the soil because of their strong adsorptivity, misapplication or tillage effects that concentrate the chemical, particularly in dry seasons, accentuate the injury on some corn plants while apparently causing no problems with nearby seedlings.

Often the pattern of application of the dinitroaniline herbicide applied to the soybean field the previous year can be observed as an injury pattern in the corn--particularly when applied in a diagonal pattern.

Reduced tillage practices such as using only a field cultivator to prepare the corn seedbed result in minimal movement of the concentrated herbicide. Thus, when a corn seed germinates and attempts to develop a root system in the dinitroaniline concentration, it remains stunted and develops slowly.

We have never had a reported case of dinitroaniline carryover on corn where a moldboard plow was used as a primary tillage tool on soybean stubble. We have had few problems where chisel plowing was followed by two diskings in the spring. Our main concern is in drougthy years where "minimized" tillage was used in a reduced tillage program.

CLOSED SYSTEMS FOR AERIAL SPRAYING

R.W. Brazelton, N.B. Akesson, S.W. Boos

Why Closed System

When regulatory actions and insect tolerance caused the many pesticides relatively harmless to humans to be replaced by the organophosphates and carbamates, the highly toxic nature of these new materials offered potential for increased hazard to pesticide handlers and users. Reported instances of injuries and illnesses led to the initiation in California of extensive and continuing studies of doctors' first reports of injury.

These studies did indeed point to reports of pesticide injuries and illnesses among those persons actually involved in the day-to-day handling and use of toxic pesticides though many initial reports proved to be invalid. The first such study covered 1973 when 199 cases related to aircraft operations were recorded. Detailed references to pesticide illness and injuries among workers and results of cholinesterase testing and medical effects of closed systems to date are included in the paper "Pesticide Accident Histories in California" elsewhere in these proceedings of the Thirtieth Illinois Custom Spray Operators Training School.

A review of the statistics (Table 1, 2, and 3) indicates that injury frequency, as one might expect, relates to extent of exposure, with the largest number of illnesses occurring to ground applicators, mixers and loaders, field workers, and nursery or greenhouse workers. For aerial operators, then, this points to the need for eliminating contact by mixers, loaders, and flaggers with toxic materials during handling and application operations.

In California rather extensive worker safety regulations were adopted first on an emergency basis in January of 1974 and later on a permanent basis to cover all aspects of pesticide operations, but only those dealing with closed system techniques for handling Category I toxic liquid materials (word DANGER on the label) will be discussed here.

If personnel most directly involved in handling toxic materials are those most frequently injured, and if long-term experience indicates that education alone has not effectively corrected the problem, the logical solution would be to provide foolproof mechanical handling systems which would eliminate hand pouring and provide for transfer of the material without exposing it to the atmosphere. Since industrial chemical plants and other industries have used such systems for many years, agricultural chemicals could be handled in a similar fashion.

Safe Container Entry

Some means of safe container entry must be devised. After entry the material can either be drained by gravity, forced out by pressure, or removed by vacuum. Pressurization is not acceptable since containers are not pressure vessels and may explode. Hence either gravity drainage or vacuum removal methods have been chosen for systems developed to date.

Table 1. Pesticide Illnesses (Aerial Operations)[a]

	Total numbers by employment 1973	1974	1975	1976
Pilots	14	17	7	8
Flaggers	20	6	16	14
Loaders	165	141	143	122
Aircraft total (agriculture)	199	164	166	144

[a]State of California, Department of Food and Agriculture and Department of Health.

Table 2. Pesticide Illnesses (Other Than Aircraft)

	Total numbers by employment 1973	1974	1975	1976
Agr. ground applicators	424	225	264	254
Field worker re-entry	157	112	167	156
Gardeners (commercial)	66	103	106	159
Nursery, greenhouse	112	73	90	119
Fumigator (field)	71	29	22	14
Machine maintenance	22	28	40	26
Tractor drivers, irrigators	..	23	22	30
Drift exposure	26	22	31	29
Others	..	7	1	19
Totals (other than aircraft)	878	622	743	806

Table 3. Pesticide Illness (First Report of Illness)

	Total numbers by employment 1973	1974	1975	1976
Total all of agriculture	1,077	786	909	950
Total other than agriculture	397	371	434	502
Grand total for year	1,474	1,157	1,343	1,452
Pct. by agriculture employees	73%	68%	68%	65%

Design Problems

While a number of systems have been "approved" for present use, most are not yet truly "closed." The problem lies in the design of the container closure. More than forty container types are in common use, none of which utilizes the truly "closed system" type of access fittings commonly used on toxic material containers in other industries. The success of a container closure would depend on its ability to prevent escape of material from an agricultural chemical container. Since modification and standardization of containers will be a very long process, the application industry must work around this weakness of the system. Another formidable problem is that any external container closure change would require Department of Transportation approval.

Criteria for Closed Liquid Pesticide Mixing Systems

The California requirements for a closed system can best be described by the existing criteria (8/8/77):

1. The liquid pesticide concentrate shall be removed from its original shipping container and transferred to the mix tank or application vehicle tank by a closed system of hoses, pipes, and couplings that connect directly or are sufficiently tight to avoid exposure of any person to the pesticide concentrate and rinse solution.

2. All hoses, piping, tanks, and connections used in conjunction with a closed liquid pesticide mixing system shall be of a type appropriate for the pesticide, pressure, and vacuum to be encountered.

3. All sight gauges shall be protected against breakage. External sight gauges shall be equipped with valves so that the pipes to the sight gauge can be shut off in case of breakage or leakage.

4. The closed system shall provide adequate measurement of the pesticide being used. Measuring devices shall be accurately calibrated to the smallest unit in which the material is being weighed or measured. During the rinsing operation, consideration must be given to any liquid remaining in the transfer lines since it may effect accuracy of measurement.

5. The movement of a pesticide concentrate, beyond a pump by positive pressure, shall be at a pressure not to exceed twenty-five (25) pounds per square inch.

6. When a probe is used, it shall *not* be removed until the container is emptied and the inside of the container and the probe have been flushed with water in accordance with paragraph 8 below.

7. When the suction hose is detached from a probe that will remain in a partially emptied container, the following procedure shall be followed:
   a. Before removing the suction hose from the probe, close the probe with a valve and purge the hose with clean water; or
   b. If the suction hose is not purged with clean water, a dry-coupler shall be installed at the hose disconnect point that will minimize pesticide drippage to not more than 2 milliliters per disconnect; or
   c. When a probe is left in a partially emptied container, it shall be closed with a valve, cap, or dry-coupler.

8. When the pesticide is to be diluted for use, the closed system shall provide for adequate rinsing of containers (with water that contains no pesticide) that have held less than 60 gallons of a liquid pesticide.
   a. The rinsing system shall be capable of spray rinsing the inner surfaces of the container and the rinse solution shall go into the pesticide mix tank or applicator vehicle via the closed system.
   b. Water at a minimum of 15 pounds pressure per square inch shall be used for rinsing.
   c. The rinsing must be continued until a minimum of one-half of the container volume or 10 gallons, whichever is less, of rinse solution has been used.
   d. The rinse water must be removed from the pesticide container concurrently with the introduction of the rinse water.
   e. Pesticide containers shall be protected against excessive pressure during the container rinse operation. The maximum container pressure shall not exceed five (5) pounds pressure per square inch.

9. Each commercially produced closed system or component to be used with the closed system shall be sold with a complete set of instructions on its operation. These instructions shall consist of a functional operating manual and a decal or system of decals placed on the system covering the basic operation.

It should be noted that these criteria are not considered to be the *only* possible list of techniques. Provisions have been made for California's Department of Food and Agriculture to consider possible approval of other approaches which will accomplish the same purpose.

Punch and Drain

At present two of the systems approved for use in California use the following method. The pesticide container is inserted into a chamber which is then sealed. A hollow punch then cuts a large opening in the container allowing all of the material to drain into a sump or the mixing tank. A water nozzle portion of the hollow punch then sprays the inside of the container to thoroughly rinse it. Rinse water drains to the mix tank. The cleaned container is then removed for disposal. The system comes close to being a truly "closed" one, but has the drawback that only full container quantities can be used. No partial container use followed by storage of the remainder in its original container is possible, but storage in an intermediate measuring tank is quite possible providing that the tank is properly secured when not in use.

Suction Systems

Most systems extract the material by suction through the use of some sort of probe which is inserted into the container. Such systems must meet certain requirements:

1. There should be no pesticide loss, yet maximum protection to the worker while transferring chemicals from the shipping containers to sprayers or mix tanks. This can be accomplished by;

(a) Use of a double concentric tube (probe) which cuts through the plastic seal of a double-cap opening after the protective shipping cap is removed by hand (shown at A on Figure 1).

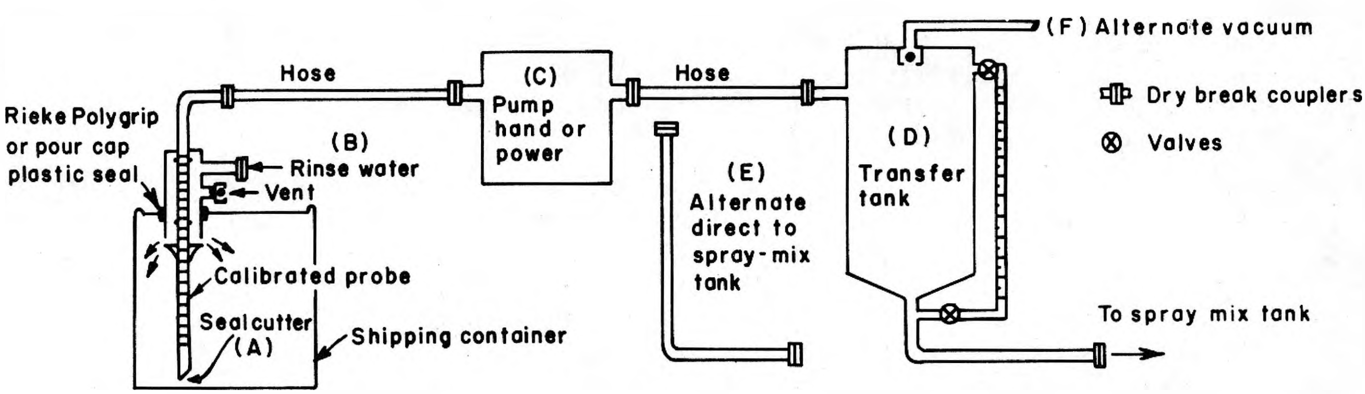


Figure 1. Alternate systems schematic.

(b) Use of a sharpened container punch probe with a round control seal around the probe to enter any type of metal or plastic container, or other system which seals the container opening around the probe.

(c) Use of a support frame to hold small containers upright while probes are in use.

2. The transferring of the contents from the container to the mixing tank may be accomplished by:

(a) Transferring the pesticides first to an elevated and calibrated holding tank by the use of either a pump (C), or by vacuum (F) provided by a vacuum pump or the input side of an operating pump, or from a venturi or jet-pump device in the discharge of an operating pump circulating the spray mixture.

(b) Transferring the pesticides directly to the mixing tank from full containers containing precisely measured contents.

3. The pesticide should be measured to insure proper dosage. Ways to accomplish this are by:

(a) Transferring the pesticide to an elevated tank (D) calibrated with a sight gauge to indicate specific quantities which can be released into the mix tank.

(b) Using a fixed-volume stroke hand or powered pump which moves a known quantity of material with each revolution (C through E).

(c) Using a calibrated (marked) probe for the specific size container, so that pushing it into the can a given distance will allow the pesticide to be withdrawn down to the probe level (A). Note that accuracy of this system may not be adequate for measuring small amounts, and a recording system must be set up to keep track of material left in the container.

4. When emptied, the container and the transfer system must be rinsed with clear water so that there is no contamination hazard. To accomplish this, pump fresh water through the outside tube of the probe (B) to rinse the container. The rinse liquid is withdrawn at the same time to prevent rupture of the container. If a container is only partially emptied, the probe must be left in place until the container is emptied and rinsed.

Dry break couplers with positive shut-off of the uncoupled hose are used to connect the probe to the transfer system. Dry break couplers permit safe connection of the system to a different container without removal of the probe. Containers should be supported to prevent accidental tipping, and leveled if a calibrated probe is to be used.

The problem of partially emptied containers can be greatly alleviated by more careful estimation and purchase of pesticides. Since label recommendations for applying a pesticide allow a range of dosage used, the pest control advisor or the grower may adjust the amount per tankful or the amount of the entire acreage treated to a purchasable unit amount. One gallon shipping containers may greatly assist in reducing the problem of leftover pesticides.

Advantages of Closed Systems

The use of closed systems for handling the more toxic agricultural chemicals would have the following advantages: (1) increased worker safety, which contributes to an improved public image for applicators; (2) use of uncomfortable protective clothing may no longer be necessary; (3) complex medical supervision may be reduced to a simple initial base line cholinesterase test; and (4) more accurate pesticide measurement will reduce the danger of excess residue or poor results from insufficient application. Reducing waste of expensive pesticides may produce substantial cost savings.

Systems for the Aerial Operator

While eight or more systems have been approved for use in California, the aerial operator must be aware that only some of them are adaptable to the high volume rate of operation necessary to many aerial operations. At the same time, some of the systems available have been specifically designed for such use.

The aerial operator normally may use a multiple-use nurse truck or trailer to transport water and other material to the job site. Components of some of the systems available can be custom mounted on such units to produce closed system capability since the key components are relatively small and easily adaptable to appropriate configurations.

The systems available have resulted from years of research by thoroughly qualified and experienced chemical applicators. Any other applicator would be well advised to contact these listed and review their systems for adaptability before deciding to "go it alone." A lot of time and money may be saved by avoiding costly "reinventing the wheel" errors even if a decision is made later to "go it alone."

The systems currently approved for use are provided by the manufacturers listed below:

Blackwelders
101 Blackwelder Drive
Rio Vista, CA 94571
Attn: John Kincheloe
(707) 374-6441

Coastal Ag-Chem
1015 East Wooley Road
Oxnard, CA 93030
Attn: Earl Griffin
(805) 487-4961

FMC Corporation
Agricultural Machinery Division
222 East 14th
Ripon, CA 95366
Attn: Don Nelson
(209) 599-4147

Protect-O-Mfg. Company
Star Route, Box 8337
West Highway 126
Redmond, OR 97756
Attn: Cal Butler
(503) 548-5446 or
382-6886

Soilserv Inc.
1427 Abbott Street
Salinas, CA 93901
Attn: Hugh Shaw
(408) 422-6428

Specialty Steel Fabricating
(Goodwin System)
2314 S. Hollenbeck Road
Stockton, CA 95206
Attn: Jim Soares
(209) 463-6082

Squire Farm Service
2931 Tully Road
Hughson, CA 95326
Attn: Ralph Squires
(209) 883-2283

Terminator Products
(Calibrator)
1550 105th Avenue
Oakland, CA 94603
Attn: Jim Stevenson
(415) 638-3654

FUNGICIDE SEED TREATMENTS FOR SMALL GRAINS

D.H. Scott

For a number of years, seed treatment has been considered cheap insurance and a sound cultural practice for wheat and other small grains. Seed treatment, clean seed, good seedbed preparation, balanced soil fertility, timely planting, and the use of disease-resistant, well-adapted varieties have all been widely known suggestions for good crop growth and production. In 1971, however, the amount of wheat and other small grains treated with a seed-treatment fungicide started to decline. This happened in part because of the loss of the commonly used liquid organic-mercury seed-treatment fungicides, the availability of improved disease-resistant grain varieties, and the use of certified high-quality seed. From 1971 to 1974, alternatives for the organic mercury seed treatments were suggested, but there was no strong Extension effort in Indiana to encourage their use.

Then in 1974, trace amounts of common bunt (stinking smut) were found in a few scattered Indiana wheat fields. In 1976, new races of the loose smut fungus had developed in the state, and all Arthur wheat types were susceptible to the new races. Both common bunt and loose smut are potentially damaging seed-borne diseases, and infected seed can not be differentiated from healthy seed except by laboratory procedures. Thus, Extension programs once again strongly suggested that wheat seed be treated with a seed-treatment fungicide that would control common bunt and loose smut as well as seedling blights.

The seed-treatment fungicides currently registered for use in Indiana are given in Table 1, along with the diseases they will control. Some seed-treatment fungicide uses may vary from state to state, depending upon state regulations; therefore, check with your local Extension agent or state Extension plant pathologist for individual state recommendations. Illinois recommendations are given elsewhere in this manual.

A wheat seed-treatment fungicide testing program was started at Purdue in 1974 to evaluate new, experimental fungicide seed treatments and selected registered products for yield and effectiveness of control of seedling blights and common bunt. Loose smut evaluations were also made but are not included because the artificial inoculation procedures were only partially effective.

Data for the wheat seed-treatment trials harvested in 1977 are given in Table 2. In these trials, the cultivar 'Oasis' was used for stand and yield determinations and 'Monon' was used for the bunt control test. Wettable powder fungicides were applied as slurries. Liquid or flowable formulations were applied directly to 100-g lots of Oasis or to 50 g of Monon seed that had been previously inoculated with teliospores of *Tilletia foetida*. The stand and yield tests were replicated four times in two-row plots 2.5 m long. The bunt tests were replicated twice in single-row plots 2.5 m long. Row widths were 30 cm, and 1 g of seed was sown per 30 cm of row. All plots were planted on October 12, 1976, in the same field of Chalmers silty clay loam at Purdue University Agronomy Farm, West Lafayette, Indiana. Percent stand was estimated visually on March 15, 1977, and the plots were harvested by combine on June 30, 1977. The number of heads with and without bunt were counted on June 8, 1977.

Soils were abnormally dry and cool at time of planting. Consequently, wheat emerged slowly and went into the winter with only one leaf emerged. The MEB 6447 treatment emerged especially poorly. Despite an extremely cold winter there was little winter kill of plants, and the percent stand values reflect differences in emergence rather than winter survival. Only seed treated with BAY-KWG 0519 at 0.3 g/kg emerged better than the untreated seed. Several other fungicides significantly reduced stands. Where phototoxicity was evident, it was related to dose. Seed that had been shaken in a jar without fungicide to determine the extent of seed injury from the slurry application technique had slightly less emergence than untreated seed, but not significantly so.

Although stands were about 50 percent, many plots yielded well. None of the treatments significantly increased yield above the control, but six treatments significantly reduced yields. Eight treatments yielded more than the "shaken, no fungicide" treatment. This application method was probably more injurious to seed than a commercial slurry treater, so these treatments might have yielded more than the untreated control had a gentler application method been used.

All treatments had significantly less bunt than the control. As we found last year, Ortho Drill Box Wheat Seed Protectant was the only commercially registered product in the trial that completely eliminated bunt. Fourteen treatments reduced bunt to 0.5 percent or less.

Table 1. Registered Fungicides for Wheat Seed Treatment[a]

Fungicide and trade name	Formulation[b]	Application[b]	For control of[c] Seedling blight	Bunt	Loose smut	Rate[d]
captan						
Captan 25 Seed Protectant[e] (25% captan)	D	PB	X	0	0	3.0B
Captan 75 Seed Protectant[f] (75% captan)	WP	S	X	0	0	0.66B
Captan 80 Seed Protectant[f] (80% captan)	WP	S	X	0	0	0.66B
Captan-Methoxychlor 75-2 Seed Protectant (75% captan; 2% methoxychlor)	WP	S	X	0	0	0.66B
Evershield Captan-Malathion Seed Protectant (29.25% captan; 0.34% malathion)	L	S	X	0	0	See label
Orthocide 75 Seed Protectant (75% captan)	WP	S	X	0	0	1.25P
Orthocide 75 Seed Protectant Dust (75% captan)	D	D,PB	X	0	0	1.5P
Orthocide 4 Flowable Seed Protectant (37.2% captan)	L	S	X	0	0	1.75P
Ortho Isotox Seed Treater[e] (12.5% captan; 25% lindane)	D	D,PB	X	0	0	2.0P
Orthocide Malathion 75-1 Seed Protectant (75% captan; 1% malathion)	WP	S	X	0	0	1.25P
Orthocide Methoxychlor 75-3 Seed Protectant (75% captan; 3% methoxychlor)	WP	S	X	0	0	1.25P
captan-hexachlorobenzene (HCB)						
Ortho Drill Box Wheat Seed Protectant (20% captan; 20%HCB)	D	D,PB	X	X	0	2.0B
carboxin						
Vitavax[g] (75% carboxin)	WP	D,S	X	X	X	2.0-3.0P
Vitavax Flowable[h] (34% carboxin)	L	S	X	X	X	2.0-3.0P

See last page of Table 1 for footnotes.

Table 1. (Continued)

Fungicide and trade name	Formulation[b]	Application[b]	For control of[c] Seedling blight	Bunt	Loose smut	Rate[d]
carboxin (cont.)						
Vitavax 200[h] (17% carboxin; 17% thiram)	L	S	X	X	X	3.0-4.0P
hexachlorobenzene (HCB)						
Orthocide HCB Seed Protectant (37% HCB)	L	M,S	0	X	0	1.0B
maneb						
Dithane M-22 (80% maneb)	WP	D,S,PB	X	X	0	1.25B
Dithane M-22 Special (80% maneb + zinc salt)	WP	D,PB	X	X	0	1.25B
Dithane M-45 Seed Protectant (80% maneb + zinc)	WP	D,S	X	X	0	1.3B, slurry 2.0B, dry
Granol N-M (50% maneb; 18.75% lindane)	D	PB	X	X	0	2.0B
Manzate (80% maneb)	WP	D,PB	X	X	0	2.0B
Manzate-D (80% maneb + zinc salt)	WP	D,PB	X	X	0	2.0B
Manzate-200 (80% maneb)	WP	D,PB	X	X	0	2.0B
maneb-hexachlorobenzene (HCB)						
Clean Crop M50-H10 (50% maneb; 10% HCB)	D	PB	X	X	0	1.0B
Granox N-M (50% maneb; 10% HCB)	WP	S,PB	X	X	0	1.0B
Granox Liquid (25% maneb; 5% HCB)	L	L,S	X	X	0	1.6B
pentachloronitrobenzene (PCNB)						
Terra-Coat LT-2[j] (24% PCNB)	L	L,S	X	X	0	2.0B
Terra-Coat 2-LF[j] (24% PCNB)	L	L,S	X	X	0	2.0B

Table 1. (Continued)

Fungicide and trade name	Formu-lation[b]	Appli-cation[b]	For control of[c]			Rate[d]
			Seedling blight	Bunt	Loose smut	
pentachloronitrobenzene (PCNB) (cont.)						
Terra-Coat L-205 (23.2% PCNB; 5.8% terrazole)	L	L,S	X	X	O	2.0B
Terra-Coat SD-205 (20% PCNB; 5% terrazole)	D	PB,S	X	X	O	2.0B
TCMTD						
Busan 30 (30% TCMTD)	L	L,S	X	X	O	0.75B
thiram						
Arasan 75 (75% thiram)	WP	D,S	X	X	O	1.3B
Arasan 50-Red (50% thiram)	WP	D,S	X	X	O	2.0B
Arasan 70-S (70% thiram; 2% methoxychlor)	WP	D,S	X	X	O	1.3B
Evershield Thiram Seed Protectant (29.52% thiram)	L	S	X	O	O	See label

[a]List of Registered Chemicals obtained from Indiana State Chemist's office as of July, 1977.
[b]D=Dust; L=Liquid; M=Mist; PB=Planter Box; S=Slurry; WP=Wettable Powder.
[c]X=Control; O=Does not control.
[d]B=ounces per bushel, P=ounces per 100 pounds.
[e]May be used on previously treated seed.
[f]May be used in combination with most pesticides except strongly alkaline materials.
[g]May be used with captan or thiram. Do not graze or feed livestock on treated areas for six weeks after planting.
[h]Do not tank-mix with any pesticide. May be used on previously treated seed. Do not graze or feed livestock on treated areas for six weeks after planting.
[j]Primarily for Rhizoctonia.

Read and follow all label directions and precautions. Do not use treated seed for food or feed or mix with untreated grain for sale. The information given herein is supplied with the understanding that no discrimination is intended and no endorsement by the Indiana Cooperative Extension Service is implied.

Table 2. Effect of Chemical Seed Treatment on Stand Establishment, Yield, and Bunt

Material	Dose	Monon Bunt	Oasis Stand	Oasis Yield
	g/kg	*%*	*%*	*kg/ha*
Untreated		39.3	48	4,650
Shaken, no fungicide			41	3,756
Vitavax 200	1.9	2.3	46	4,764
	2.5	1.4	40	4,294
Vitavax Flowable	1.3	6.7	45	4,089
	1.9	3.3	44	4,500
Orthocide-Vitavax HB 20-20	1.9	3.3	55	4,447
	2.5	10.9	53	4,682
Orthocide-Vitavax WP 37.5-37.5	1.3	7.2	50	4,759
	1.9	1.4	56	4,411
Ortho Drill Box Wheat Seed Protectant	2.1	0	50	4,368
Ortho Wheat Seed Protectant Flowable	1.6	.4	50	4,168
RH-2161	.6 ai	2.1	34	4,526
MEB 6447 (Bayleton) 2 ST	.6 ai	.5	31	3,722
	1.3 ai	.2	20	3,219
	1.9 ai	0	13	3,258
	2.5 ai	0	9	1,789
Mertect LSP 30%	.5	18.0	43	4,643
	1.0	5.7	45	4,511
	2.1	2.3	38	3,547
	4.2	.3	33	4,139
Terrachlor + Vitavax WP	3.1	0	45	4,563
Terrachlor + Tachigaren WP	1.0	0	45	4,168
Terrachlor + zinc omadine WP	3.1	0	51	4,265
Tachigaren 70 WP	2.1 ai	.6	44	4,243
UBI 1160	.6	20.3	..	..
	1.3	12.3	60	4,485
	2.5	1.1	58	4,642
UBI 1130	.6	15.1	..	..
	1.3	2.6	43	4,117
	2.5	.3	50	4,700
UBI 1143	1.9	12.3	..	..
	3.8	1.2	..	..
BAY-KWG 0519 25 ST	.3	0	63	4,541
	.6	0	44	4,568
	1.3	0	34	3,961
LSD (.05)		3.3	15	793

CONTROL OF PERENNIAL WEEDS

M.D. McGlamery

Why are perennial weeds on the increase in corn and soybean fields? Most soil-applied (preplant and preemergence) herbicides do not control perennial weeds. The spread of perennial weeds has been favored by changes in tillage and cropping programs. Chisel plows and field cultivators can drag root fragments of perennial weeds. Reduction in row cultivation and elimination of small grains and forage legumes from the rotation have also allowed perennial weed populations to increase.

What are the worst perennial weeds in corn or soybeans? A 1974 survey of weed problems in Illinois ranked yellow nutsedge as the worst perennial weed; common milkweed, quackgrass, johnsongrass, and Canada thistle were ranked fairly severe. Other problem perennial weeds were field bindweed, hedge bindweed, climbing (honeyvine) milkweed, wild sweet potato (bigroot morningglory), wirestem muhly, and trumpet creeper. Jerusalem artichoke, hemp dogbane, and swamp smartweed are sometimes reported as problems in corn and soybeans. Multiflora rose is often a problem in fields and pastures, while wild garlic and wild onion are problems in winter wheat and pastures in southern Illinois.

How do perennial weeds spread and reproduce besides from seeds? Creeping perennial weeds can vegetatively reproduce by underground parts (propagules) such as rhizomes, tubers, budding roots, or bulbs. Perennials that reproduce by rhizomes are quackgrass, johnsongrass, wirestem muhly, and yellow nutsedge. Yellow nutsedge also has tubers (nutlets) by which it overwinters. Tuberous broadleaf perennials are wild sweet potato (bigroot morningglory) and Jerusalem artichoke. Wild garlic and wild onion have underground bulbs and aerial bulblets. Most perennial herbaceous broadleaf weeds have budding roots.

Effective perennial weed control practices should prevent seed production from established plants; eliminate seedlings before propagules form; expose propagules to freezing or drying; kill propagules with translocated herbicides; or deplete food reserves by destroying top growth. The best control programs usually involve a combination of tillage, cropping practices, and chemicals.

Properly timed repeated tillage will eventually deplete underground food reserves. The cutting of rhizomes or roots into small segments will cause more buds to sprout. Tillage should not drag rootstocks into uninfested areas. Row crop cultivation can also help control perennial weeds.

Cropping programs may be modified for choosing more effective control programs. Preplant tillage of perennial weeds is more likely before planting soybeans than corn. Silage corn may allow postharvest tillage or spraying. Small grains that are not double-cropped or underseeded to a legume may allow control of perennial weeds after harvest. The multiple-cut schedule of alfalfa or other perennial legumes will often control many perennial weeds.

Herbicide usage and cropping programs must be compatible. Herbicides must be registered for the crop and not used at greater than labelled rates. Banvel and 2,4-D can be used in corn, small grains, and grass pasture; higher rates can be used on grass pastures. Sutan+ and Eradicane can be used for suppression of rhizome johnsongrass and quackgrass and control of johnsongrass seedlings and yellow nutsedge only in corn. Atrazine can be used at high rates for control of quackgrass, yellow nutsedge, Canada thistle, and Jerusalem artichoke in corn, but you should not grow of soybeans or small grains the next year.

Lasso and Basagran can be used to control yellow nutsedge in both corn and soybeans, while Dual is at present cleared only in corn. Roundup is the only nonselective translocated herbicide cleared for cropland use. Currently, it must be used before the crop is planted or after it is harvested, since it is not cleared for spot treatments. The development of the recirculating sprayer, herbicidal glove, "weed wiper," or other selective placement may allow its use while growing row crops.

Here are some principles you should know about translocated herbicides. Translocation to the roots is greatest when food is being stored in the roots. This is often at the early bud stage or late fall growth. Do not apply fall treatments on warm-season perennials after frost. Quackgrass and wild garlic are examples of cool-season perennials. Translocation is best when the plant is actively growing and translocating food to the roots. Do not apply during drouthy or extremely cool weather. Do not apply translocated herbicides with "contact" herbicides. Applying excessive rates of translocated herbicides may kill translocating tissue. Retreatment is more effective than using high rates. Several annual treatments may be necessary for best control.

Control programs for Canada thistle, johnsongrass, yellow nutsedge, and wild garlic are given in the "1978 Field Crop Weed Control Guide" in this manual. There are no effective control programs in corn and soybeans for common milkweed, hemp dogbane, or honeyvine (climbing) milkweed. Roundup can be used on regrowth after small grain harvest. Rotating to alfalfa for two or three years will also help control these weeds.

Field bindweed and hedge bindweed can be partially controlled in corn by applying 2,4-D with drop nozzles when the bindweed has fully expanded leaves. Jerusalem artichoke can be controlled in corn with split applications of preemergence and postemergence atrazine, or split applications of postemergence 2,4-D. Wild sweet potato (bigroot morningglory) can be controlled in corn by spraying 2,4-D at the early bud stage of the weed. However, early bud stage often occurs during the silking to soft dough stage of corn, and corn is quite susceptible to 2,4-D injury during this stage. This application requires the use of high clearance equipment. Banvel will provide control of swamp smartweed in corn.

Wirestem muhly control is similar to quackgrass control; however, wirestem muhly begins growth later in the spring than quackgrass. Delayed planting of corn, or planting soybeans and using preplant tillage or Roundup, have helped control wirestem muhly.

Multiflora rose can be controlled in pastures with a mixture of 2,4-D and 2,4,5-T (brush killer). Tordon or Krenite can be used in fencerows or noncropland. Poison ivy can be controlled in fencerows and noncropland with the use of amitrole or 2,4,5-T.

"MIRACLE" PRODUCTS IN AGRICULTURE

R.G. Hoeft, L.V. Boone

The art of medicine men has not been lost. They continue to ride the circuit. The main difference between the medicine men of today and those of years ago is that laws have now forced them away from curing the ills of humans and into curing the ills of soils and plants. Their mode of transportation has changed; they can move in, make the sale, and disappear faster now. Although their techniques are more sophisticated because of improved "technology," the basic selling point--that their product can cure all ills--still exists.

"Miracle" products can generally be grouped into one of several different classifications: (a) organic amendments, (b) mineral amendments, (c) microbial inoculants, (d) low-volume and low-analysis fertilizers and herbicides, and (e) wetting agents. According to promoters, these products will among other things: chelate metals, help control frost and dew, improve drainage and the root system, increase the protein content and the water holding capacity, loosen hard soils, neutralize both acid and alkaline soils, or fix nitrogen. In addition, "miracle" products are supposed to: be in a completely available form, provide a natural source of nutrients and release nutrients from the soil, encourage more earthworms, reduce run-off and soil crusting, provide disease and insect resistance, or produce drier grain and higher yields.

Classifications

Organic Amendments

This group of compounds consists of products that generally contain organic materials such as kelp (seaweed), humic acid (generally derived from a low-grade lignite coal), molasses, and composted or microbiologically digested plant or animal materials.

Claims made for these products are far-reaching. In some instances a single product will "hasten maturity of some crops," while at the same time it will maintain other crops, particularly grasses, in a vegetative state later in the fall. These products not only increase yield, but they also, "reduce disease and insect problems, promote better rooting, make the soil easier to till," and so on.

Some of these products contain several elements that have not been shown to be essential to plant growth. Some of these elements, such as cobalt, lead, and sodium, can actually be detrimental to plant growth. This is seldom if ever a problem since the concentration of these nonessential elements, like the concentration of the essential elements that the product may contain, is far below that necessary for either toxicity or beneficial effects. If one were to supply all of the essential plant nutrients with any of the organic amendments currently on the market, the cost of transporting the products to where they are needed may well be greater than the value of increased crop production resulting from using the product.

Mineral Amendments

The major materials within this group are granite, silica (sand), bentonite, kaolinite, vermiculite, calcitic limestone, dolomitic limestone, and gypsum. The last three of these materials are recommended for Illinois soils under some situations. However, none of the other materials in this group has to date been shown to be beneficial for crop production in Illinois. Interestingly, many of the benefits claimed for these products are similar to those claimed for the organic amendments.

Both dolomitic and calcitic limestone are beneficial for crop production when applied to acid soils. However, they have not been shown to increase crop yield when applied to neutral or calcareous soils. Gypsum (calcium sulfate) is beneficial when applied to soils high in sodium if drainage can be obtained to leach the sodium from the profile. The only soils having a problem with high sodium content in Illinois are naturally-occurring "slickspots" and those located near oil wells where there has been a salt spill. Therefore, application of gypsum as a soil amendment is recommended only in a very few situations. Gypsum can also be used as a source of sulfur, but the extent of sulfur-deficient soils in Illinois is very limited.

Microbial Inoculants

Many strains of bacteria, fungi, actinomycetes, and algae are currently marketed for application to soil. Some of these are purported to contain improved or mutated strains that are more effective than naturally-occurring organisms in releasing "bound" soil nutrients, fixing nitrogen, or improving the tilth of the soil. Some promotional material implies that these naturally-occurring organisms have been destroyed by the current use of chemicals or that the present populations in the soil are not adequate to perform the stated function. Other promotional materials do not acknowledge the fact that the organisms being "supplied" by their product are already present in the soil.

Low-Volume and Low-Analysis Fertilizers and Herbicides

It has been well documented that the proper application of a particular fertilizer or herbicide at the proper rate will result in increased crop production. In recent years, however, some groups claim that, because of seemingly mystic formulations, they are selling a product that will supply much more effective nutrients or herbicides. These groups claim that you can use a smaller amount of their product and obtain the same result you could by using the recommended rate of a conventional material. These sales programs have been successful, in part at least, because some people have been misinformed about the meaning of the analyses given on a fertilizer label. The numbers on the label are the percent of available nutrients, <u>not</u> pounds of available nutrients in the container. For example, a 7-24-20 means that 7 percent of the material is available nitrogen (N), 24 percent is available phosphate (P_2O_5), and 20 percent is available potash (K_2O). It does not mean, as some groups have implied, that a gallon of such a product contains 7 pounds of N, 24 pounds of P_2O_5, and 20 pounds of K_2O. In fact, a gallon of liquid fertilizer which weighs about 10 pounds, will contain only about one-tenth that much of each element.

Two of the most frequent claims made for low-volume and low-analysis fertilizers and herbicides are that the material is in solution and thus is more readily available, and that the product, because of its chemical make-up, is not fixed after being applied to the soil. Neither of these claims can be substantiated by research data. Agronomists generally agree that a pound of nutrient will provide a given yield response if it is properly applied, regardless of the source. Some products such as raw rock phosphate, are obviously not as readily available as, for example, ammoniated phosphates or triple superphosphate. Companies marketing low-analysis herbicides have often conveniently neglected to state that users must increase the rate of application to obtain the same control they would obtain with another product having a higher analysis.

Wetting Agents

Wetting agents, or surfactants, have been available and in use for several years to aid the effectiveness of herbicides. In recent years the number of these products has markedly increased. Some of these new products claim to have an influence on soil water-holding capacity, infiltration rate, porosity, or the release of "unavailable" nutrients in the soil. It is interesting that some claim both to reduce the potential for wet soils and at the same time to increase water holding capacity. Availability of research data to substantiate these claims is either very limited or nonexistent.

Research results

Almost all of these questionable products currently being marketed are promoted through the use of farmer testimonials or information collected from demonstration plots. While this information may be valid, it is not sufficient to determine the efficacy of a product. Similarly, such information rarely, if ever, provides the type of comparisons necessary to identify the mode of action of the product, that is, the cause of the yield increase. It is usually impossible to tell whether any increase was due to use of the product or to some other factor perhaps not even associated with using the product.

Companies marketing these products almost never substantiate their claims with data collected by an unbiased agency. When asked to provide such information, they frequently imply that the research agencies require too much money to test a product or that the agencies simply refuse to test the product. Research studies are expensive because they are very labor intensive. At the present time agricultural technology is changing at such a rapid pace that governmental agencies do not have adequate resources to research all new ideas that are proposed. They must therefore select those having the highest probability of success based on the theory supporting the product or practice.

What is meant by unbiased research, and why is it important that the results be unbiased? "Unbiased" simply means that the persons collecting the information have no financial or personal interest in the product or practice, and that they have no interest in a competitive product. Few people are not influenced, be it knowingly or unknowingly, by a financial or personal interest in anything they do. It is therefore best to trust information collected by persons who will receive no personal or financial benefits from supplying either positive or negative research results. Disinterestedness tends to encourage the researcher not only to ascertain the efficacy of the product, but also to identify the mode of action of the product.

Even though the theory behind many of these products would not justify expenditure of research effort, intense interest has provided the incentive for testing of some of them. Results from several of these studies are shown in Tables 1 to 3.

Table 1. Effect of "Organic Amendments" on Corn Yield

Treatment	Yield (bu./A.)
Illinois	
Organic amendment (lb./A.)	
0	104
1,000	97
10,000	97
100,000	104
Wisconsin	
Control	125
Organic amendment	110
South Dakota	
No treatment	54
Organic amendment (200 lb./A.)	59
N (60 lb./A.) + P (13 lb./A.)	64

Table 2. Effect of "Microbial Additives" on Corn Yield

Treatment	Yield (bu./A.)
Illinois	
No treatment	64
Microbial additive	70
Ammonium nitrate (150 lb. N/A.)	175
Kentucky	
No treatment	127
Microbial additive "A"	127
Microbial additive "B"	126

Table 3. Effect of Low-Volume Additives on Corn Yield

Pounds per acre				
N	P_2O_5	K_2O		Yield (bu./A.)
Wisconsin[a]				
0	0	0		140
3	6	3	as specialty fertilizer	143
9	18	9	as specialty fertilizer	141
9	36	36	as conventional fertilizer	153
18	72	72	as conventional fertilizer	156
Kentucky				
0	0	0		36
9	18	9	as specialty fertilizer	44
120	130	104	as conventional fertilizer	119

[a]In addition to the treatments listed, all Wisconsin plots received 115 lb./A. of N and 100 lb./A. of K.

Lack of significant yield response to application of these "miracle" products is the only consistent conclusion that can be drawn from the various studies. In many instances the use of these products in accordance with the company recommendation, which, for example, may be to omit conventional fertilizers, has resulted in substantial yield reductions.

Chemical analyses of many of the products have shown that the nutrient concentration of the product is markedly lower than that of the soil to which it is being applied, so the product may in fact dilute soil nutrients rather than improve the fertility. Analysis of many of the microbial additives has shown that the additives may not contain viable cultures of the stated organisms. The lack of organisms may be due to quality control in packaging or to loss of viability in the process of marketing.

Summary

"Miracle" products have been available to farmers for many years and will probably continue to be marketed in the future. To date few of these products have survived either the research tests or sustained use by farmers. Agriculturists are always looking for new products or practices to improve the efficiency of crop production. However, before recommending, selling, or using a new product, one should have evidence that it has potential value.

KEEPING INSECT PESTS OUT OF YOUR HOUSE

D.A. Gentry

For many years chlordane has been the standard foundation spray used to reduce the chance that nuisance insects such as crickets, spiders, and ants will enter homes and businesses. The U.S. Environmental Protection Agency's suspension order on the use of chlordane for this purpose has stopped production, and existing supplies are limited. Only chlordane manufactured before July 29, 1975, and bearing a label for this purpose may be used legally.

In 1977 a study was undertaken to compare the effectiveness of several insecticides as a replacement for chlordane as a foundation spray. The insecticides were chlordane (Gold Crest C-100 72 percent EC), propoxur (Baygon 1.5 EC), diazinon (Diazinon 4E), microencapsulated diazinon (Knox-out FM), chlorpyrifos (Dursban 2E), and bendiocarb (Ficam W). Propoxur, diazinon, chlorpyrifos, and bendiocarb have labels for foundation spraying. Chlordane was included as the standard for comparison. Microencapsulated diazinon has an experimental use label.

Sterile soil samples were treated with 1-percent solutions at a rate of 1.4 fluid ounces per square foot. This equals 1 gallon of spray per 100 square feet. The samples were placed outside in mid-May on the south side of a building to allow for normal weathering. Bioassays using house crickets, *Acheta domestica*, were conducted at intervals of one, three, five, eight, and eleven weeks. The crickets were confined on the treated soil smaples for 24 and 48 hours.

24-Hour Bioassay

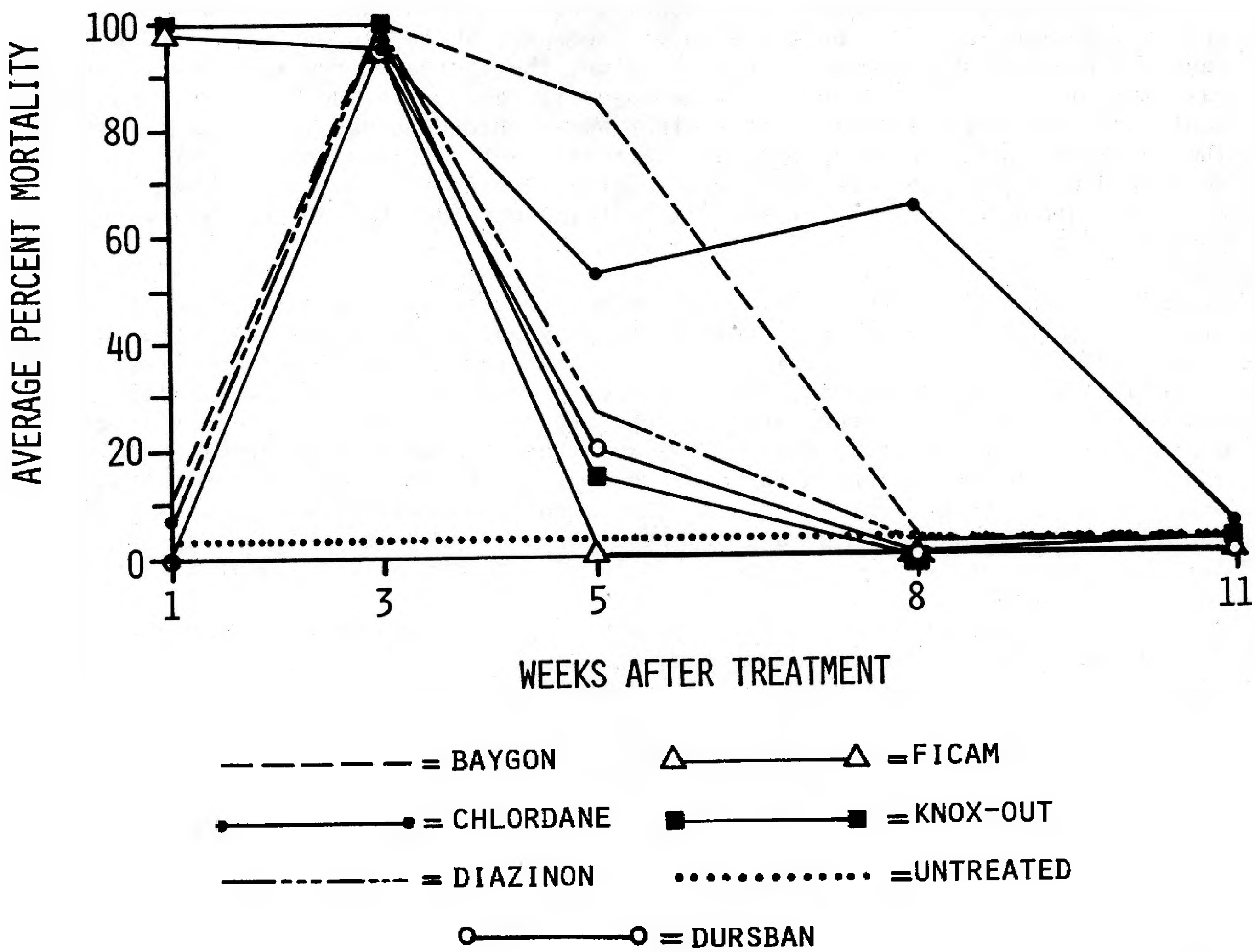
Table 1 and Figure 1 show the average mortality rate of house crickets exposed to the treated soil for 24 hours. Between the time of treatment and the first bioassay, no precipitation was recorded; the average temperature for the week was 77°F. Under these dry conditions bendiocarb (Ficam) and microencapsulated diazinon (Knox-out) produced a high mortality rate (97.5 to 100 percent). Chlordane, propoxur (Baygon), diazinon, and chlorpyrifos (Dursban) showed poor control (10 percent or less) for 24 hours. The lack of moisture may have been an important factor in the slow action of chlordane, propoxur, diazinon, and chlorpyrifos. Just before the three-week bioassay, precipitation of 0.36 inch was recorded, and the soil samples were wet when brought into the laboratory. All six insecticides produced a high mortality rate, that is, between 95 to 100 percent, during 24 hours.

Five-week bioassay results show early chemical degradation. Precipitation had been light (0.48 inches) during the interval between the three- and five-week tests. Propoxur (Baygon) caused the highest mortality (85 percent), with chlordane falling to 52.5 percent and the other insecticides dropping below 30 percent. Eight weeks after treatment chlordane showed about the same level of control (65 percent) as it had at five weeks. Results for the five remaining insecticides dropped below the 5-percent mortality level. Precipitation between the five- and eight-week bioassays was very high, with 3.54 inches of rain recorded. Two inches of rain fell the week before the bioassay. The heavy rainfall may have been a major factor in reducing

Table 1. Average Mortality Rate of House Crickets Exposed to 1-Percent Solution Treatments of Various Insecticides for 24 Hours

Weeks after treatment	Chlordane	Baygon	Diazinon	Dursban	Ficam	Knox-out	Untreated
			percent				
1	2.5	10.0	5.0	0	97.5	100.0	2.5
3	95.0	100.0	100.0	95.0	95.0	100.0	2.5
5	52.5	85.0	27.5	20.0	0	15.0	2.5
8	65.0	2.5	2.5	0	0	0	2.5
11	5.0	2.5	2.5	0	0	2.5	0

Figure 1. Average mortality rate of house crickets exposed to 1 percent solution treatments of various insecticides for 24 hours.



the effects of the insecticides more rapidly than usual, although the rainfall did not have that effect on chlordane. After eleven weeks of exposure to the weathering process, all of the treatments showed less than 15-percent mortality for the 24-hour bioassay.

48-Hour Bioassay

Table 2 and Figure 2 show the average mortality rate of house crickets exposed to the insecticide treatments for 48 hours. In all cases the increase in exposure time increased the mortality rate. After one week's exposure mortality was very high, ranging from 90 to 100 percent. The increased exposure time compensated for the lack of moisture. At the three-week bioassay, all insecticides showed high levels of control similar to the 24-hour bioassay, that is, from 97.5 to 100 percent.

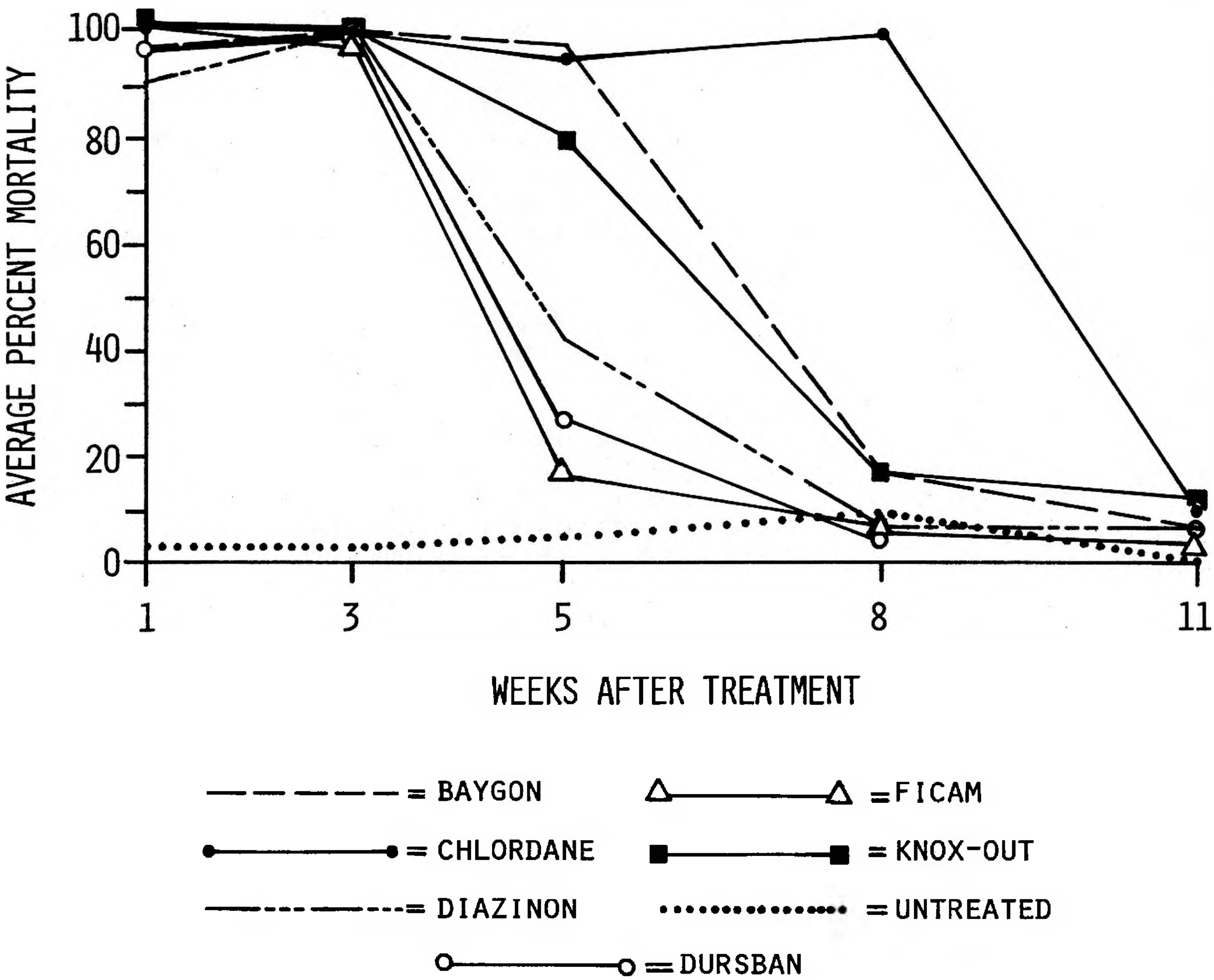
At five weeks the crickets were affected less by the increased exposure time than at one week. Chlordane, propoxur (Baygon), and microencapsulated diazinon (Knox-out) provided high mortality levels (80 to 97.5 percent). Diazinon, bendiocarb (Fican), and chlorpyrifos (Dursban) dropped below 50 percent, ranging from 17.5 to 42.5 percent. The longer exposure to chlordane and microencapsulated diazinon did result in a higher mortality rate than the 24-hour exposure. Chlordane caused a 42.5-percent increase between the 24- and the 48-hour exposure, while microencapsulated diazinon caused a 65-percent increase. In comparison, the increase from the longer exposure was small (7.5 to 17.5 percent) for propoxur (Baygon), diazinon, chlorpyrifos (Dursban), and bendiocarb (Ficam). After eight weeks chlordane was 100 percent effective The remaining insecticides produced a mortality rate of less than 20 percent. As mentioned earlier, heavy rainfall was recorded during this period. By the eleventh week of weathering, effects of the six test insecticides had dropped below the 15-percent mortality level.

Around the home a high level of control needs to be maintained. The long residual effect of chlordane reduces the number of spray applications per year, and is therefore beneficial because it minimizes the contact time between applicator and chemical. If chlordane is not available, the homeowner should use diazinon at labeled rates and methods. It may be necessary to repeat the application at four-week intervals during the summer and early fall. Propoxur (Baygon) and microencapsulated diazinon (Knox-out) do not have labels for homeowner use, but their residual activity was longer than that of the other chemicals with the exception of chlordane. Propoxur, labeled for use by PCO only should do a good job if applied professionally. Microencapsulated diazinon (Knox-out) does not have an EPA label and cannot be used at this time.

Table 2. Average Mortality Rate of House Crickets Exposed to 1-Percent Solution Treatments of Various Insecticides for 48 Hours

Weeks after treatment	Chlordane	Baygon	Diazinon	Dursban	Ficam	Knox-out	Untreated
			percent				
1	100.0	97.5	90.0	97.5	100.0	100.0	2.5
3	100.0	100.0	100.0	100.0	97.5	100.0	2.5
5	95.0	97.5	42.5	27.5	17.5	80.0	5.0
8	100.0	17.5	7.5	5.0	7.5	17.5	10.0
11	10.0	7.5	7.5	7.5	5.0	12.5	0

Figure 2. Average mortality rate of house crickets exposed to 1-percent solution treatments of various insecticides for 48 hours.



IRRIGATION PRINCIPLES AND COSTS FOR ILLINOIS

M.D. Thorne

Every section of Illinois normally receives more water as rain and snow during a year than it loses by evaporation from the soil and transpiration from plants. Nevertheless, there is never a year when soil moisture is not deficient for optimum crop growth sometime during the growing season.

Together, soil evaporation and plant transpiration are known as evapotranspiration. Potential evapotranspiration is the loss when conditions would be most conducive to evaporation and transpiration.

In an average year, potential evapotranspiration exceeds precipitation from May to September. Crops will grow during this period if one or more of the following conditions prevail: (a) stored soil moisture is sufficient to make up the deficit during the growing period; (b) actual evapotranspiration is reduced appreciably below potential evapotranspiration; (c) additional water is added by irrigation.

Crops growing on deep soil with high water-holding capacity may get by quite well if precipitation is not appreciably below normal and if the soil is filled with moisture at the beginning of the season. Fine-textured soils with a high organic-matter content have good water-holding capacity.

Evapotranspiration can be reduced by getting fast early growth to help shade the soil, by mulching, or perhaps by using transpiration retardants. When soil moisture is limiting, evapotranspiration is reduced, but yields are usually reduced also.

Periods of below-normal rainfall in the summer are also usually periods of above-normal temperatures, and soil moisture may become severely limiting. Data from Iowa State University have shown as much as 40 percent reduction in yield of corn from four consecutive days of visible wilting at the time of silk emergence. Their studies have also shown yield reductions of soybeans as much as 40 percent from drought during the week after pod filling begins.

Rain Probability in Illinois

It takes at least 20 inches of water to produce a good crop of corn in Illinois.Various sections of the state get from 10 to 15 inches of rain during the growing season. Thus, 5 to 10 inches of subsoil moisture are needed in an "average" year to produce the yields we have come to think of as normal or satisfactory. If the rainfall during the growing season is below normal this year, more than 8 inches of stored soil moisture would be needed. The result will be lowered yields, unless we can add additional water by irrigation.

Unfortunately, the probability of getting at least an inch of rain per week is lowest in all sections of Illinois during the time corn is normally pollinating--the last half of July. Irrigation can prevent moisture deficiencies during this and other critical periods in crop growth.

Yield Increases From Irrigation

We now have three years of data from irrigation research on sandy soil in Mason County. Corn yields slightly higher than 200 bushels per acre were obtained on irrigated land in 1975 and 1976. The yields fron nonirrigated land in the experiment for those years were 70 to 80 bushels. In 1974, the high yield was 180 bushels per acre; yields from nonirrigated land were not obtained in the experiment that year. Irrigated full-season soybeans yielded 55 and 45 bushels per acre in 1975 and 1976. The yields from nonirrigated land in those years were 30 and 16 bushels, respectively. Irrigated soybeans yielded 58 bushels per acre in 1974; no yields were taken that year from nonirrigated land. Double-crop soybean yields were obtained each year from plantings made the first week in July. The highest yields obtained for double-crop soybeans in each year ranged from 25 to 30 bushels per acre.

Another prediction of the yield increases that might be expected from irrigation in Illinois if the stored soil moisture plus rainfall is inadequate can be obtained by using the crop model developed at the University of Illinois and the University of Missouri during the past few years. This model is being used to predict corn yields at various locations in the Midwest.

If we assume that we will encounter "normal" temperature and rainfall conditions during the growing season and if we have only 4 inches of stored soil moisture available at planting time, the model predicts yield increases of 35 to 60 bushels of corn per acre as the result of adding 4 more inches of water by irrigation during the growing season. If we make the same assumptions but have only 4 inches of stored soil moisture at planting time, the model predicts increases of 40 to 80 bushels per acre from adding 8 inches of water by irrigation.

Cost of Irrigation

The best data we now have on the cost of irrigation come from the University of Nebraska. For 1976, the total cost of irrigating field corn with a center-pivot system was about $79 an acre per year, with capital equipment costs of $56 an acre per year and operating costs of $23 an acre per year. These figures do not include a cost for land or for other expenses not directly associated with irrigation. Nor do they include extra seed corn, extra fertilizer, or other increased costs that may be associated with irrigation yield increases.

The total cost of producing corn in Nebraska under irrigation in 1976 was about $274 per acre. This figure included a cost of 6 percent for land evaluated at an average of $450 per acre. The breakeven corn price for irrigated corn production in 1976, given those costs, was $2.19 per bushel for a yield of 125 bushels per acre, or $1.83 per bushel for a yield of 150 bushels per acre.

The cost of irrigating corn will probably be over $80 an acre per year for the 1978 season. The cost of irrigating soybeans or pasture or vegetable crops in Illinois will not differ appreciably from the cost of irrigating corn. Thus, one can compute the yield increase that would be required to pay for the added cost of irrigation by dividing the figure of $80 per acre by the expected price per unit of the crop.

If the capital costs of an irrigation system run $400 per acre (including the well, power source, etc.) and land costs $2,000 per acre, the irrigation cost amounts to 16.7 percent of the total. If the land cost is $4,000 per acre, the irrigation cost becomes 9.1 percent of the total. Irrigating existing acreage now under your management will help stabilize your production from year to year and might also be considered in relation to purchasing or leasing additional land.

Other Considerations in Deciding To Irrigate

If a producer is convinced that it will be profitable for him to install an irrigation system, he must have an adequate source of water. Such sources do not now exist in many parts of the state. We are fortunate that underground water resources are generally good in the sandy areas where irrigation is most likely to be needed. Most of the irrigation development to date has been in these sandy regions.

A relatively shallow well in some of these areas may provide enough water to irrigate a quarter section of land. In some areas of Illinois, however, particularly in the northern third, deeper wells may be needed to provide a relatively adequate source of water for irrigation.

Many farmers are pumping their water from streams for irrigation. This can be a relatively good, low-cost source; but, of course, the steam may dry up in a drought year.

Impounding surface water on an individual farm is possible in many areas of the state, and some farmers are doing that. However, an appreciable loss may occur both from evaporation and from seepage into the substrata. The rule-of-thumb figure is that you probably need to store 2 acre-inches of water for each acre-inch actually to be applied to the land. One acre-inch of water equals 27,000 gallons.

In many areas, water-development costs are likely to be beyond the range of feasibility for an individual farmer. However, such development by groups of farmers, cooperatives, or governmental agencies could produce a sufficient water supply in one containment for a number of irrigators.

At present, no permit is required in Illinois to use water for irrigation. Riparian doctrine governs the use of surface waters; that is, in brief, a person is entitled to a reasonable use of the water that flows over or adjacent to his land, as long as he does not interfere with someone else's right to use the water. No problem results as long as there is plenty of water for everybody. However, when water becomes limiting, legal determinations may have to be made as to whether one's use interferes with someone else's rights. It may be important to have a legal record established in order to verify the date on which the use of water for irrigation began.

Now, assuming you believe it will be profitable for you to irrigate and you have an assured supply of water, how do you find out what type of equipment is available and what will be best for your situation? University representatives have discussed this in various meetings around the state, but they cannot, of course, design a unique system for each farm. Your county Extension adviser can give you a list of dealers in Illinois and others nearby who serve Illinois. This list gives the kinds of equipment each dealer sells but will not give you information about the characteristics of those systems.

We suggest that you contact as many dealers as you wish and discuss your needs with them in relation to the type of equipment they sell. You will then be in a much better position to determine what equipment to purchase. To the best of our knowledge, there are no independent consulting irrigation engineers or agronomists in the state at present, only staff members employed by irrigation manufacturers, dealers, or universities.

Management Requirements

Irrigation will provide maximum benefit only when it is an integral part of a high-level management program. Good seed or plant starts of proper genetic origin planted at the proper time and at a sufficiently high plant population, accompanied by optimum fertilization, good weed control, and other recommended cultural practices, are necessary to assure maximum benefit from irrigation.

Farmers who invest in irrigation may become disappointed if they do not manage the irrigation properly. They often overextend their systems so much that they cannot maintain adequate soil moisture when the crop requires it. For example, the system may be designed to apply 2 inches of water to 100 acres once a week. In two or more successive weeks, soil moisture may be limiting, with potential evapotranspiration equaling 2 inches per week. If the system is used on one 100-acre field one week and another field the next week, neither field may receive much benefit. This is especially true if moisture stress comes at a critical time. Inadequate production of marketable product may result.

Currently, we suggest that irrigators follow the practices they would use to obtain the most profitable yield in a year of ideal rainfall. In many parts of the state, 1975 was such a year. Other years have been nearly ideal in some sections of Illinois. If your yield is not already appreciably above your county average, you probably need to improve your management of other production factors before you invest in an irrigation system.

HOW HERBICIDES WORK

Richard Behrens

For effective weed control, herbicides must (a) contact the weeds, (b) be absorbed, (c) move within the weed to the site of action without being deactivated, and (d) build up to toxic levels at the site of action. The application method used, that is, preplanting incorporation, preemergence, or foliar, determines whether the herbicide will contact the germinating seeds, the roots, or the shoots of the weeds. Protecting the crop from injury often depends on application of the herbicide so that its contact with the crop is held to the minimum. For example, when 2,4-D is sprayed on small grains, very few of the spray droplets that strike the upright leaves will stick to the leaves, so contact with the crop is small. On the other hand, most of the spray droplets striking the larger exposed surface of the horizontal leaves of broadleaf weeds stick on the leaf surface, so contact is great. Contact is also a major factor in soil application because most of the weed seeds that will germinate are located in the 1/2-inch surface, while larger seeded crops are planted 1 or more inches deep. Herbicides applied on the soil surface are much more likely to come in contact with germinating weed seeds located near the soil surface than with crop seeds located deeper in the soil.

Once in contact with the plant, the herbicide is absorbed mostly through the roots or leaves. Root uptake may continue for long periods if the herbicide remains in contact with the absorbing region near the root tips. Usually as roots penetrate to greater soil depths, herbicide contact with the absorbing area of the root is reduced, and herbicide uptake declines. Therefore, weeds that are not killed before root tips grow out of the soil layer where the herbicide is located are likely to survive. Shoot absorption of many soil-applied herbicides occurs while the shoot is still underground. Volatile herbicides (e.g., thiocarbamates and dinitroanilines) that have been incorporated in the soil penetrate the emerging shoots as gases and kill or seriously injure the shoot before it emerges from the soil. The rate of herbicide absorption by emerged plant shoots varies greatly. The chemical attraction or repulsion between the leaf surface and the herbicide often determines the rate of uptake. For example, 2,4-D esters have an affinity for leaf waxes and are rapidly absorbed, that is, within a few hours. There is much less attraction between 2,4-D amines and the leaf waxes, and absorption may continue for days. This difference is important if rainfall occurs a few hours after the herbicides are applied. The 2,4-D ester treatment would be effective because the herbicide was absorbed before the rain, while the 2,4-D amine treatment would be ineffective because the rain would have washed it from the leaves before it could be absorbed.

The movement of herbicides within plants also varies greatly. Some herbicides, for example paraquat, remain very close to the point of entry and exert their toxic effect on adjacent plant tissues. Others, for example atrazine and cyanazine, move upward only in the plant. These herbicides are carried upward in the water transport system (xylem) of the plant and concentrate in the leaves. A third type, which includes 2,4-D and dicamba, can move both upward and downward in the plant. These herbicides move in the food transport system to the growing points of the shoot and root.

Plants that rapidly destroy or deactivate a specific herbicide can escape its effects. Corn is tolerant of the triazine herbicides because it quickly destroys the triazine molecules. The deactivation process differs in that the herbicide molecule is not destroyed. Instead, it is bound to another molecule within the plant so that it cannot exert its toxic effect. Soybean tolerance to metribuzin is at last partly due to deactivation of metribuzin when it is bound to glucocide molecules.

An understanding of how some of the more widely used herbicides work may be helpful to you in selecting a good weed control program. Though each of the many herbicides now available differs from all others, some share similarities in herbicidal activity and chemical properties that allow us to group them into "families." Below we will consider characteristics of herbicide families that may be helpful in deciding which compound to use and how to use it most effectively for your weed problems.

Some of the most important herbicide families are: (a) hormone herbicides, (b) triazines, (c) amides, (d) thiocarbamates, and (e) dinitroanilines.

Hormone Herbicides

The most widely used hormone herbicides are the phenoxy acids, 2,4-D and MCPA, and the benzoic acid, dicamba (Banvel). These herbicides disrupt the auxin hormone system, which controls growth in plants. Hormone herbicides are most effective on broadleaf weeds and most active when applied to the foliage. However, 2,4-D and dicamba are also effective when applied to soil at higher application rates. Once taken into the plants through the leaves or roots, these herbicides move upward or downward to the growing points of the shoots and roots and kill the new growth or cause it to be malformed. Best results are obtained by treatment of seedlings or young plants that are growing vigorously. Weeds growing poorly because of cold temperatures, wet soil, or water and nutrient shortages may survive treatment with these herbicides and eventually recover. If possible, under poor growing conditions, delay the herbicide application until conditions improve. Also, use the maximum allowable application rates to increase herbicide uptake by plant foliage. Rapid destruction by microorganisms in the soil prevents accumulation in the soil carryover problems with the herbicides mentioned above.

Triazines

The triazines, atrazine and cyanazine (Bladex), are used extensively on corn. Another member of this family, metribuzin (Lexone or Sencor), is now being used on soybeans. These herbicides are most effective in controlling annual broadleaf weeds, but will also control a number of grassy weeds. They are absorbed by shoots or roots and translocate upward into leaves, where they destroy the food production mechanism. This results in the death of leaves and eventually to the plant. Corn escapes injury by destroying the triazines so rapidly that toxic levels do not build up on corn leaves. Soybean tolerance to metribuzin is not as great as corn tolerance to atrazine and cyanazine. Soybean tolerance is due to deactivation by binding of metribuzin to other compounds within the soybean plant.

Preemergence applications of the triazines are most often used. For satisfactory weed control, rainfall of 1/2 inch or more is necessary within 10 days to disperse the herbicide through the soil layer where the weed seeds are germinating. Under dry conditions preplanting incorporation or shallow incorporation of preemergence applications improves weed control. Incorporation substitutes in part for rainfall in distributing herbicide through the soil area where it can be absorbed by the roots of weed seedlings.

Limited leaf penetration occurs when foliar applications of atrazine and cyanazine are used. To improve weed control, leaf absorption can be increased by adding crop oil or surfactants. However, use of the additives also increases the possibility of corn injury. Rainfall following foliar treatments improves grassy weed control by leaching these herbicides into the soil so that foliar uptake is supplemented by root uptake. Atrazine persists in the soil and may affect crops planted the following year. Persistence is greater in a cool, dry season. Under these conditions it is best to grow corn a second year to avoid carry-over injury that might occur if atrazine-sensitive crops are grown.

Amides

Important amide herbicides used in the Midwest are alachlor (Lasso) and propachlor (Ramrod). They give excellent control of most annual grassy and a few broadleaf weed species in corn and soybeans. A new member of this family, metolachlor (Dual), has recently been introduced for use on corn and soybeans. The amides work best when applied to the soil before weed emergence. They are dispersed in the soil by mechanical incorporation or by rainfall. They enter weed seedlings through shoots or roots and prevent further plant growth by blocking the production of plant protein. Many weed seedlings are killed before they emerge from the soil. Those that emerge have malformed leaves that remain in a tight roll. Plants tolerant to the amides have the ability to quickly degrade these herbicides to harmless metabolites, so that toxic levels do not develop. Soil persistence or carry-over is not a problem with these compounds.

Thiocarbamates

EPTC (Eptam), butylate (Sutan), and vernolate (Vernam) are thiocarbamates that have been used extensively in recent years. EPTC and butylate are used on corn, and vernolate is used on soybeans. These compounds are more effective on grassy than on broadleaf weeds. They are applied to the soil and require thorough soil incorporation very soon after application to prevent loss by volatilization. Adequate soil incorporation is difficult and volatilization is greater when the soil is wet; as a result, weed control may be poor if these herbicides are applied to wet soil.

The thiocarbamates are most effective in controlling germinating seedlings. These compounds act on plants by stopping the production of new cells. Seedlings that emerge are usually malformed and stunted and their leaves fail to unroll. To provide adequate safety for corn, a protectant must be applied to the corn seed or applied in a mixture with Eptam and Sutan. Formulations containing the protectant are now available. The thiocarbamate herbicides disappear from the soil by the end of the growing season under normal weather conditions.

Dinitroanilines

The more important dinitroaniline herbicides are trifluralin (Treflan), profluralin (Tolban), dinitramine (Cobex), and fluchloralin (Basalin). Their major use in field crops is to control annual grasses and some broadleaf weeds in soybeans. Incorporation soon after application is necessary to prevent their loss from the soil as a vapor. These herbicides are incorporated in the soil, so rainfall is not required for activation. They readily penetrate the shoots before emergence. Most sensitive weed seedlings are killed before they emerge from the soil. By disrupting cell division, these herbicides cause stunting, malformation, and death of sensitive plants. The rate of disappearance of these herbicides from the soil is reduced at low soil moisture and temperature. Under such unfavorable conditions sensitive crops planted the following year may be injured.

NEW CORN ROOTWORM INSECTICIDES

R.E. Sechriest, G.K. Roskamp

Procedure

Cornfields at Urbana and Macomb that were late-planted in 1976 and attractive to northern and western adult rootworms during August, 1976, were selected for insecticide evaluation during 1977. The experiments were randomized blocks with three replicates at Urbana and four replicates at Macomb. Individual plots were single rows approximately 90 feet long. Granular treatments were applied by a Gandy applicator on single International unit planters. Band applications were made with a 7-inch Gandy RoBander, with the bander placed half the distance between planter shoe and press wheel. This location meant that no insecticide was placed on the seed, but the insecticide was incorporated into the upper inch of soil. For furrow applications the insecticide was placed directly on the seed in the shoe. Basal applications were made on June 1 at Urbana and June 6 at Macomb. Two tubes from the applicator were used to deliver half of each treatment to each side of the row as a post-emergence treatment. All basals were hand-incorporated, using a 4-pronged hoe. Sprays using emulsifiable formulations were applied by a closed air-pressure system mounted on the tractor and planter. A 6-inch band of spray placed in a similar location as the granules delivered 13 gallons per acre at 30 psi at approximately 3 mph with fan-jet nozzle No. 9502E. Planting dates were: Urbana I, May 11; Urbana II, May 11-12; Urbana III, May 25; and Macomb, May 16-17.

The experiments were evaluated by three methods. Plants per 50 feet were counted at Urbana. Five plants were dug from the soil in mid-July, the roots washed, and the root damage rated, following the 1-6 Iowa damage scale. The number of plants per 100 plants that were root-lodged more than 30 degrees were counted.

Results and Discussion

Rootworm populations were medium to heavy at both locations during 1977 except in the late-planted Urbana III experiment where the population was light (Table 1). The standards of comparison were Counter (OP) and Furadan (carbamate) as incorporated granular band treatments. In general, root-damage ratings appeared to be slightly higher in 1977 than in past years. Stand was reduced in the high 4-pound band rate of Mocap 6EC and in the furrow applications of Dotan and RhoDotan. This is the second year for phytotoxicity and reduced stand resulting from furrow applications with Dotan. No other furrow treatments exhibited reduced germination. The incorporated band applications of Dotan and RhoDotan were not as effective as the furrow application in protecting the corn roots, especially at Urbana. In 1977 dosage rate showed little relationship to root-damage ratings. During 1977 furrow applications did not improve root protection except for Counter, for which the difference was significant. Furrow applications of Counter and Furadan generally have not improved control in the past over band applications (Table 2). Basal granular post-emergence applications of Furadan and liquid and granular applications of Oftanol showed improved control over planting-time band applications. No improvement in control was observed over band applications for flowable Furadan or granular AC-64475 as post-emergence basal treatments.

Table 1. Evaluation of Several Insecticide Formulations, Rates, and Application Techniques To Suppress Larvae of Northern and Western Corn Rootworms at Urbana and Macomb, Illinois

				Average Plants/50 ft. Urbana		Average root damage rating Urbana				Average lodging/100 plants Urbana		
Insecticide	Form.	Lb AI/A	Application	I	II	I	II	III	Macomb	I	II	III
Dotan	10G	0.5	Furrow	59.3		1.3a			1.3a	1a		
		1.0	Band	70.0b[1/]		3.2			2.2	1a		
			Furrow	12.3		1.1a			1.1a	1a		
		1.5	Band	76.0b		3.3			2.1	2a		
			Furrow	4.0		1.0a				0a		
RhoDotan	15G	0.5	Furrow	57.0		1.4a			1.8a	1a		
		1.0	Band	62.3		3.6			1.9	2a		
			Furrow	28.7		1.0a			1.3a	1a		
		1.5	Band	76.3b		3.6			2.2	1a		
			Furrow	17.0		1.0a				1a		
DS-22275	15G	1.0	Band					1.0				3
Oftanol	15G	1.0	Band		69.0b		2.7		2.3		1a	
			Furrow		72.7b		2.9		2.3		2a	
			Basal		73.7b		2.5a		2.9		2a	
	6EC	1.0	Band		66.3b		3.3		3.1		2a	
			Basal		72.0b		2.8				1a	
Furadan	10G	1.0	Band	72.3b	76.0b	3.2	3.1	1.1	2.2	1a	5a	2
	4F	1.0	Band		60.7b		1.6a	1.2	1.7a		1a	1
			Basal		72.0b		2.8				3a	
Counter	15G	1.0	Band	67.7b	71.7b	4.0	3.1		2.9	9a	14	
AC-64475	15G	0.75	Band		64.0b		2.2a		2.7		0	
			Basal		59.3b		2.9		3.4		5a	
		1.0	Band		72.0b		2.9		2.5		3a	
			Basal		68.7b		3.8		-		18	
Akton	15G	1.0	Furrow		69.3b		4.2		2.7		13	
UC-54229	99SP	1.0	Band					1.4				4
MON-0768	10G	1.0	Band		71.0b		2.0a		2.6		0a	
		1.5	Band		74.0b		1.7a		2.3		0a	
		2.0	Band		64.3b		2.2a		2.0		0a	
		4.0	Band		67.7b		2.1a		1.7a		0a	
Mocap	10G	1.0	Band		70.0b		2.3a		2.8		0a	
	6EC	1.0	Band		62.0b		2.5a		3.2		2a	
		1.5	Band		67.0b		2.5a		-		2a	
		2.0	Band		61.0b		2.2a		3.0		0a	
		4.0	Band		55.0b		2.3a		2.4		1a	
NC-6897	10G	0.5	Band		73.3b		2.0a		2.2		1a	
		0.75	Band		70.7b		1.8a		2.1		1a	
			Furrow		70.7b		1.9a		2.0		0a	
		1.0	Band		71.3b		1.9a		1.8a		5a	
			Furrow						2.1			
	2.5G	0.75	Band		70.3b		1.9a		2.3		1a	
			Furrow						2.3			
GCP-6361	10G	0.3	Band		69.7b		2.2a				3a	
		1.0	Band		74.3b		3.0		2.2		0a	
		1.5	Band		75.0b		2.3a		1.6a			
Lorsban	15G	1.0	Band						3.0			
Dyfonate	20G	1.0	Band						2.3			
Bux	10G	1.0	Band	67.7b		3.2			2.2	1a		
CGA-12223	15G	1.0	Band						2.3			
Untreated	---	---	----	76.3b	70.3b	5.1b	4.5b	1.9	4.3b	35b	50b	5

1/ Means followed by "a" are not different from best treatment and "b" are not different from untreated (5%).

Table 2. Comparisons of Three Years of Root-Damage Ratings for Four Application Techniques at 1 Pound of Active Ingredient per Acre

Insecticide	Application	Average root-damage ratings 1977 (3 fields)	1976 (5 fields)	1975 (4 fields)	3 years
Furadan	Surface	4.3d[1/]	2.3a	---	3.3b
	Band	2.8bc	1.8a	1.4a	2.0ab
	Furrow	2.9bc	1.8a	2.2b	2.3a
	Basal	2.2a	---	---	2.2a
Counter	Surface	5.1e	2.4a	---	3.8b
	Band	3.3c	1.7a	2.3b	2.4ab
	Furrow	2.2a	1.8a	2.4b	2.3ab
	Basal	2.4ab	---	---	2.4ab
Untreated	---	4.6d	4.2b	5.4c	4.7c

1/Means (per column) with same letter do not differ at 5% level (Duncan's).

MANAGING CORN ROOTWORM POPULATIONS BY CROP ROTATION

J.T. Shaw, D.E. Kuhlman

Crop rotation has been a recommended and effective method for corn rootworm control for many years. The northern and western corn rootworms have one generation a year, with the females laying most of their eggs in the soil during August. These eggs overwinter in the soil and begin hatching the following May. Egg hatch may continue through August, but the bulk of the hatch occurs in June. Since the rootworm larvae cannot survive on roots of soybeans, broadleaf weeds, small grains, alfalfa, or sorghum, they are easily controlled by a cropping sequence in which corn is followed by a crop other than corn.

In recent years there has been some speculation that northern and western corn rootworm beetles are laying eggs not only in corn but also in other crops. Studies were initiated in Illinois in 1975 to determine the extent to which northern and western corn rootworm beetles are depositing eggs in fields of soybeans, alfalfa, and small grain.

The data in Tables 1 and 2 show the results of a two-year study for 27 soybean fields followed by corn. These fields were located in Whiteside and Stephenson Counties in northwestern Illinois. Adult northern and western corn rootworms were present in all of the soybean fields during August and early September, the intensive egg-laying period (Tables 1 and 2). Nine of the soybean fields were classified as clean fields, virtually free of weeds, and without volunteer corn; 8 were weedy fields containing predominantly velvet leaf and foxtail; 2 fields contained large amounts of broadleaf and grass weeds plus volunteer corn; and 8 fields contained volunteer corn but were relatively free of other grasses and broadleaf species.

Rootworm eggs were recovered in 12 of the 27 fields. More eggs were found in fields containing volunteer corn, but the egg-laying site was restricted in that most eggs were deposited in soil at the base of volunteer corn or near volunteer corn. Small numbers of rootworm eggs were found in 3 of the 10 weedy fields and in 1 of the 9 clean fields, though a positive attractiveness for weeds is not apparent. There was probably some egg-laying in all fields, though our method of sampling did not detect eggs in all the fields.

To assess the amount of damage caused by rootworm larvae in corn following soybeans, 20 plants were selected at random from each field and examined for root pruning. The following root rating system was used: 1 = no noticeable feeding damage, 2 = feeding scars present but no root pruning, 3 = at least one root pruned but less than an entire node of roots pruned, 4 = at least one full node of roots pruned but less than two full nodes, 5 = at least two full nodes pruned but less than three full nodes, and 6 = three or more full nodes of roots pruned. Root ratings of 2.5 or less indicate a healthy root system without economic rootworm damage.

In 9 fields classified as clean (free of weeds), only 3 of 180 roots from these fields had a damage rating of 3.0. In fields classified as weedy, 8 of 160 plants had a root damage rating of 3.0. In the remaining 10 fields, which contained predominantly volunteer corn and some weeds, 45 of 200 plants had a root rating of 3.0 or more. Thus, egg-laying and subsequent rootworm damage seems to be influenced most by the amount of volunteer corn present.

Table 1. Characteristics of Thirteen Fields of Soybeans in Northern Illinois Examined for Northern and Western Corn Rootworm Adults in August and September 1975, for Eggs in October 1975, and for Subsequent Damage to Corn Roots in 1976

Field	Field description: Volunteer corn plants/A.[a]	Weed rating[b]: Broadleaf	Weed rating[b]: Grasses	Aver. eggs/ pint soil	Highest adult counts per 100 sweeps, August 1975	Aver. root damage rating on corn, 1976
1	600	Dense	Moderate	20.2	114	1.3
2	500	Moderate	Moderate	6.7	47	1.2
3	1,000	Dense	Dense	7.8	36	1.2
4[c]	500[d]	Moderate	Moderate	.1	180	1.1
5[c]		Dense	Moderate	.7	191	1.1
6[e]		Dense	Moderate	0	91	1.1
7[c]	50	Dense	Dense	0	61	1.4
8[c]		Dense	Dense	0	241	1.5
9		Sparse	Moderate	0	143	1.2
10		Sparse	Sparse	.3	246	1.1
11		Moderate	Sparse	0	241	1.2
12		Sparse	Sparse	0	156	1.2
13		Sparse	Sparse	0	66	1.4

[a] A clump of volunteer corn was counted as 1 plant.
[b] Dense--10 or more broadleaf weeds/meter^2 or 25 or more grasses/meter^2.
Moderate--5 broadleaf weeds/m^2 or 10 grasses/m^2.
Sparse--1 or less broadleaf weeds/m^2 or 5 or less grasses/m^2.
[c] Egg samples taken at base of soybean plants and between rows of soybeans in weedy areas.
[d] Volunteer corn plants removed by the farmer during the week preceding July 31.
[e] Field was harvested and disked prior to egg sampling.

Table 2. Characteristics of Fourteen Fields of Soybeans in Northern Illinois Examined for Northern and Western Corn Rootworm Adults in August and September 1976, for Eggs in October 1976, and for Subsequent Damage to Corn Roots in 1977

Field	Field description: Volunteer corn plants/A.[a]	Weed rating[b]: Broadleaf	Weed rating[b]: Grasses	Aver. eggs/ pint soil	Highest adult counts per 100 sweeps, August 1976	Average root damage rating on corn, 1977
1	5,400	Dense	Sparse	5.0	368	4.0
2	2,000	Dense	Sparse	10.6	986	2.8
3	1,600	Sparse	Sparse	4.0	128	2.3
4	1,500	Moderate	Sparse	6.3	47	1.7
5	900	Moderate	Sparse	3.8	143	2.6
6	300[c]	Moderate	Dense	0	33	1.7
7		Dense	Dense	.1	408	2.2
8		Dense	Dense	0	47	1.5
9		Dense	Dense	0	110	1.1
10		Dense	Dense	0	43	1.1
11		Sparse	Sparse	0	198	1.5
12		Sparse	Sparse	0	38	1.2
13		Sparse	Sparse	0	36	1.0
14		Sparse	Sparse	0	54	2.1

[a] A clump of volunteer corn was counted as 1 plant.
[b] Dense--10 or more broadleaf weeds/meter^2 or 25 or more grasses/meter^2.
Moderate--5 broadleaf weeds/m^2 or 10 grasses/m^2.
Sparse--1 or less broadleaf weeds/m^2 or 5 or less grasses/m^2.
[c] Volunteer corn plants removed by farmer during the week preceding August 18.

These data confirm that a soybean-corn rotation is still effective in suppressing corn rootworms in Illinois. The rootworm damage that might occur to first-year corn following soybeans is so minimal that treatment with a rootworm insecticide is seldom necessary. The exception might be where corn is planted following soybeans that contain volunteer corn. Soybean fields with volunteer corn in excess of 1,000 plants per acre will be attractive to adult northern and western corn rootworms, and some root damage can be anticipated the following season.

The first-year results of a two-year study to determine the amount of egg-laying in alfalfa by the northern and western corn rootworms are shown in Table 3. As with the soybean fields, adult corn rootworms were very abundant in alfalfa during August, the period of intensive egg-laying. However, very few eggs were found in the alfalfa, and the root ratings on corn the following year showed no significant feeding by rootworm larvae. On the basis of one year's data, an alfalfa-corn rotation is an effective rotation for suppressing corn rootworms in Illinois. Rootworm damage to corn following alfalfa has been observed in occasional fields in past years.

Summary

The potential for corn rootworm damage in a rotation of corn following soybeans is low. Soil insecticides are rarely necessary. There are exceptions. Corn rootworms may occasionally be a problem when beetles deposit their eggs in soybean fields that contain volunteer corn; such fields when planted to corn the following year may have economic damage.

Rootworm beetles will feed on the foliage of soybean plants. They are especially attracted to soybean fields that are weedy and contain volunteer corn. Using a herbicide or clean cultivation will reduce the attractiveness of soybean fields to rootworm beetles. Clean fields of soybeans will permit soybean-corn rotations with no damage from corn rootworms.

Table 3. Density of Adult Northern and Western Corn Rootworms and Rootworm Eggs in Alfalfa in August and September 1976 in Northern Illinois

Field	Type and number of samples taken: Plug[a]	Type and number of samples taken: Trowel[b]	NCR eggs	WCR eggs	Total eggs	Aver. no. of eggs/pint	Highest adult counts per 100 sweeps: No.	Highest adult counts per 100 sweeps: Date	Aver. root rating on corn, 1977
1		10	0	0	0	0			
	10		0	0	0	0	73	8/16	c/
2		10	0	0	0	0			
	10		0	0	0	0	1,060	9/2	1.3
3		10	0	0	0	0			
	10		0	1	1	.1	1,088	8/23	1.0
4		10	0	0	0	0			
	10		0	0	0	0	434	8/10	c/
5[d]		10	0	0	0	0			
	10		0	29	29	2.9	1,192	9/1	1.0
6		10	0	0	0	0	147	8/18	1.0
7		10	0	0	0	0	662	8/20	c/
8		10	0	0	0	0	460	8/25	1.0
9		10	0	0	0	0	752	9/8	c/

a/Each plug sample consisted of 3 plugs, 2" in diameter, 2" deep (about 1 pint).
b/Each trowel sample consisted of 3 scoops of soil taken at random from base of alfalfa plants to equal 1 pint of soil.
c/Not planted to corn.
d/All 29 eggs from 1 pint sample and all were western corn rootworm eggs.

IMPACT OF SILK FEEDING BY WESTERN ROOTWORM BEETLES ON CORN GRAIN YIELD

F.T. Turpin, D. Leva, and D. Freeman

Corn rootworm beetles can affect grain yield of corn by feeding on silks during pollination. Such feeding can keep silks clipped into the shuck so that pollen grains are unable to reach the exposed silk tips, resulting in missing kernels. This condition, commonly called "scattercorn" by corn producers, can affect yields. The potential for its occurrence often encourages farmers to make a foliar application of an insecticide when beetles are present. The need for such insecticide applications is unclear at the present time.

During 1976 and 1977 we have investigated the relationship between western corn rootworm beetle populations and resulting grain yields. Most of the experiments were conducted by confining beetles on individual ears with a bridal-veil cage for various periods throughout pollination. Ears from the experiments were harvested, shelled, and weighed, and the number of kernels counted. Although neither the number of beetles nor the period of silk exposure produced significant grain reduction in 1976 (Table 1), lowest kernel counts occurred on tests with 8 or 10 beetles per silk with the fewest kernels on plants exposed to 10 beetles for the entire 12-day pollination period. Regression of number of days exposed to beetles against average number of kernels produced showed that only with 10 beetles per silk did a significant ($P < .05$) time relationship exist ($Y = 498 - 8.7\ X$, $R^2 = .50$) although the coefficient of determination of 0.50 is low.

Table 1. Damaging Effect of Western Corn Rootworm Beetle on Number of Kernels Per Ear (Pioneer Single Cross 3369).

	Kernels per ear according to silk exposure time[a]			
No. of beetles	4 days	8 days	12 days	Av.
2	477	474	477	476
4	520	464	447	477
6	487	466	487	480
8	452	420	452	441
10	448	448	386	427
Av.	476	454	450	

[a]Plants without beetles produced 484 kernels per plant.

Although kernel size compensaton in ears where kernels are missing could have reduced variation in ear weight related to beetle feeding, regression of number of kernels per ear versus ear weight showed a coefficient of determination of 0.71. This result, coupled with the fact that the greatest error occurred at the higher kernel numbers, suggests that compensation was probably not a significant determinant of ear size.

In 1977 corn inbred B73 was exposed to beetle populations ranging from 5 to 30 beetles per silk throughout the pollination period. Results (Table 2) of this study indicate that beetle populations of 10 and above per ear significantly ($P < .05$) reduce ear weight and increase the percentage of barren stalks. In 1977 as in 1976 beetle populations of 5 and below per silk slightly increase ear weight.

Table 2. Yield Response of Corn Inbred (B73) to Various Levels of Western Corn Rootworm Beetles Caged on Silks (1977)

No. of beetles	Grain[a,b] (gms.) per ear	Pct. of barren[a] stalks
0	41.7a	0a
5	47.9a	3a
10	20.3b	16a
15	13.9b	13a
20	10.9b	19a
25	11.0b	37b
30	10.9b	30b

[a]Means followed by some letter not significantly different according to Duncan's New Multiple Range Test ($P < .05$).
[b]Means based on average of 30 or more observations.

Since many beetle populations do not exceed 5 beetles per plant at the time of pollination, corn producers should weigh carefully the need to spray for rootworm beetle control. Control of such a low population is not likely to increase yield and certainly will not produce a profit.

AERIAL APPLICATIONS OF INSECTICIDES TO PREVENT ROOTWORM EGG-LAYING

R.E. Sechriest, D.E. Kuhlman, J.L. Wedberg

For four years, we have attempted to reduce rootworm populations by killing the adults before they lay their eggs. Preliminary investigations indicated that populations of northern and western corn rootworms may be suppressed with insecticides, if the sprays were properly timed to coincide with peak egg-laying. During the last two years, the success ratio has been about 50 percent. Timing of the sprays, field attractiveness, and residual of the toxicant appear to be critical.

During 1976, several individual fields were sprayed or monitored for adults (Tables 1 and 2). Larger areas of several closely associated fields were sprayed in Carroll and McDonough Counties (Tables 3,5, and 6). Plants were dug and the roots washed during July, 1977 to determine the root damage caused by the rootworm larvae. Root lodging was counted in early September. Three of the fields reported in Table 4 sprayed with carbaryl apparently showed some population control and three fields showed poor results. In the Hermes-Rt. 88 field, beetle control was poor and suppression was not expected because of high beetle counts. Near Cisco, in the Gulley and Carroll fields, two sprays of carbaryl on half of each field were successful in reducing infestations the following year. In the Cisco area, most fields were sprayed once around the third week in July; thus populations were lighter at the time of the second spray.

In the larger demonstration spray areas, beetle control was considered good. In these fields spraying was total, and no areas of the field were left unsprayed as in previous tests. One field in Carroll County (Table 5) approached the threshold level (3.0) and two fields in McDonough (Table 6) were at the problem level or higher. In McDonough County, three fields received the second carbaryl spray but one of those still had sufficient infestation to pose a problem in 1977. This was similar to the Hermes-Rt. 88 field north of Sterling.

During the 1976 and 1977 spraying seasons, the carbaryl spray appeared to have an effective life of 2 to 2-1/2 weeks. With this residual life expectancy, two sprays seem necessary to provide any consistent measure of population reduction. The first spray should be applied in mid- to late July (depending on the season), and the second spray should be applied when the beetle count reaches the economic threshold of 0.3 gravid female beetles per ear zone.

At present, we are unable to insure consistent successful rootworm beetle suppression with the adulticide approach. MSR, Furadan, and Imidan did not suppress the population the following year. As one can observe in the tables, some root damage should be expected even when the adults have been sprayed. Several insecticides will provide pollination protection, but no insecticides so far have demonstrated a consistent pattern of population reduction the following year in Illinois. Thus most farmers will still use a soil insecticide.

Table 1. 1976 Adult Rootworm Control Using Carbaryl 4-Oil, Evaluated by Number of WCRW Beetles per Plant

Field	Town	WCRW M/F	Sprayed		Pre-spray	4 days	1 wk.	2 wk.	3 wk.	4 wk.	5 wk.
					WCRW adults per plant						
Reeder	Monticello	44/51		X[a]	10.3	5.0	..	..	2.1	..	..
			7-23	T	..	.1	..	..	1.2	..	.4
Warren	Farmer City	6/26		X	..	..	.8	..	.3	..	..
			7-23	T	..	..	.4	..	.3	..	..
Gulley-N	Cisco	..	7-22	T	10.0	.1	..	..	(EZ)[b] .9	..	.8
Gulley-S	Cisco	..		X	15.0	..	..	..	..	..	..
			7-22	T	..	.3	..	..	..	..	..
		5/9		X	..	..	..	..	(EZ)1.5	1.0	.6
			8-10	T	..	..	..	..	(EZ) ..	0	0
Verbout	Sheffield	30/41		X	2.1	..	3.2	1.1	..	1.1	..
			7-29	T	..	..	.7	1.1	..	1.1	..
Hermes-Rt.88	Sterling	30/14		X	6.5	..	4.3	3.9	..	2.8	..
			7-29	E	..	..	.2	2.4	..	2.0	..
		47/30	8-17	B	..	..	.2	5.2	3.0	.1	..
			8-17	L	..	..	1.3	5.6	5.0	.1	..
Lee	Monmouth	22/23		X	1.6	..	..	1.0	.1	..	..
			8-2	T	..	..	.2	.3	.5	..	..
Gillen	Monmouth	16/17		X	1.4	..	.1	1.0	.3	..	..
			8-2	T	..	..	0	1.1	.4	..	..
Pfister	El Paso	..		X	..	..	.5	1.2	.5	..	..
			8-6	T	..	..	.2	.4	.5	..	..

[a] X = Untreated, T = treated, E = early treatment, L = late treatment, B = early and late treatments.
[b] Beetles per ear zone.

Table 2. 1976 Adult Corn Rootworm Control With Four Insecticides Evaluated by Number of WCRW Beetles per Ear Zone

Field	Town	WCRW M/F	Sprayed		Pre-spray	4 days	1 wk.	2 wk.	3 wk.	4 wk.	5 wk.
					Carbaryl 4-oil						
Kratz	Monticello	..	7-22	T[a]	3.0	.1	..	..	.2	.1	.5
Burnside	Monticello	51/56	none	X	2.6	3.3	..	..	1.6	.9	1.0
Robinson-E	Monticello	..	none	X	1.7	2.6	..	..	1.4	2.0	1.4
Robinson-W	Monticello	..	none	X	2.7	2.1	..	..	2.7	1.5	.5
Roberts	Monticello	..	none	X	1.1	1.4	..	..	1.4	.8	.7
Reeder	Monticello	44/51		X	3.0	1.5	..	..	2.7	2.2	.4
			7-23	T	..	.1	..	..	1.5	1.2	.4
Warren	Farmer City	6/26		X	..	.6	1.1	..	.4	..	.9
			7-23	T	..	0	.3	..	.1	..	.1
Trimble	Farmer City	63/23	none	X	..	1.3	1.7	..	.2	..	.5
Verbout	Sheffield	30/41		X	1.2	..	1.6	.6	1.6	.2	..
			7-29	T	..	..	.3	.1	1.5	1.1	..
Hermes-Rt.88	Sterling	30/14		X	4.0	..	2.1	2.1	.	2.0	1.7
			7-29	E	..	..	.3	.8	..	.8	1.0
			7-29	B	..	..	.1	1.5	2.4	.1	0
			7-29	L	..	..	1.8	1.7	3.0	.1	0
Lee	Monmouth	22/23		X	.9	..	.5	.5	.7	..	..
			8-2	T	..	..	0	.3	.3	..	..
Gillen	Monmouth	16/17		X	1.7	..	.3	.4	.3	..	..
			8-2	T	..	..	0	.5	.2	..	..
Pfister	El Paso	..		X	.9	1.2	.9	.2	.6	..	..
			8-6	T	..	.2	0	.3	.4	..	..
					Imidan						
			8-3	T	..	.2	.1	.5	.4	..	..
Jontz	Buda	29/26		X	2.0	..	1.9	2.3	.6	..	..
			8-3	T	..	..	.1	.2	.7	..	..
					Furadan						
				X	2.0	..	2.8	2.2	1.0	..	..
			47 1/4	T	..	..	..	..	..	..	..
			47 1/8	T	..	..	.5	1.9	.9	..	..
			10G		..	..	.8	1.5	2.2	..	..
					Metasytox R						
Hermes-(Sauk)	Sterling	12/23		X	2.4	2.1	1.4	3.2	2.3	..	..
			7-30	T	..	2.3	1.4	2.3	1.7	..	..
Carroll	Cisco	7/22		X	1.0	..	.8	.7	.7	..	..
		(2nd spray)	8-13	T	..	..	0	0	0	..	..

[a]X = Untreated, T = treated, E = early treatment, L = late treatment, B = early and late treatments.
[b]Beetles per ear zone.

Table 3. Control of Corn Rootworm Beetles With Carbaryl 4-Oil, 1976, McDonough County, Illinois

			Number of rootworm beetles per plant				
Field no.	Treatment	Lb. a.i./A.	8/2[a]	8/10	8/17	8/24	9/1
4-1	none	..	9.06	2.9	2.42	.98	.42
2-3	carbaryl 4-oil	1	6.64	.06	.42	.40	.02
2-4	carbaryl 4-oil	1	9.62	.04	.36	.76	.06
2-1 (West)	carbaryl 4-oil	1	7.42	.12	.44[b]	0	0
2-2 (East)	carbaryl 4-oil	1	8.36	0	.36[b]	.04	0
6-5 (West)	carbaryl 4-oil	1	8.00	0	.48[b]	.04	0
6-5 (East)	carbaryl 4-oil	1	6.10	0	.30[b]	0	0

[a]Pretreatment counts, August 2; all fields except 4=1 were sprayed by helicopter on August 3, 1976

[b]Fields 2-1, 2-2, 6-5 (West and East) received a second application of carbaryl 4-oil on August 18.

Table 4. Evaluation of Adult Corn Rootworm Population by Root Damage Ratings and Percent Lodging, 1976-1977

	1977 root damage ratings					Percent lodging			
	1976 air treat.		1976 untreated			1976 air treat.		1976 untreated	
Field	Soil treat. 1977	No treat. 1977	Soil treat. 1977	No treat. 1977	1977 soil insecticide	Soil treat. 1977	No treat. 1977	Soil treat. 1977	No treat. 1977
	carbaryl 4-oil								
Kratz	1.4	2.6	..	..	Furadan	3	4	..	..
Robinson-E	..	..	1.4	4.1	Counter	..	..	0	9
Robinson-W	..	..	2.8	5.4	Counter	..	..	3	55
Reeder	2.2	3.5	2.6	..	..	2	1	0	0
Verbout	1.6	2.6	3.2	3.3	Counter	9	38	39	99
Hermes-Rt. 88									
Untreated	..	..	1.5	3.4		..	..	1	28
Early	2.4	4.1	..	..	Dyfonate	2	4	..	..
Both	1.9	4.1	..	..		0	7	..	..
Late	1.3	2.6	..	..		2	14	..	..
Lee	2.6	5.5	2.1	5.5	Dyfonate	2	73	3	73
Gillen	1.9	4.6	2.4	5.0	Counter	0	22	0	38
Pfister	1.1	1.9	1.7	4.1	?	0	0	0	0
	Imidan								
	1.6	4.5	1.7	4.1	?	0	0	0	0
Jontz	1.6	3.1	3.1	..	Counter	19	78	..	..
	Furadan								
F@1/4	1.3	3.6	1.3	4.7	Counter	13	28	37	95
10G	1.3	3.6	1.3	4.7	Counter	7	25	37	95
	MSR								
Hermes (Sauk)	4.2	4.3	3.8	..	Dyfonate	0	0	0	..
	carbaryl 4-oil								
	2 sprays		one spray						
Gulley	1.2	1.3	1.5	2.9	Counter	0	0	6	11
Carroll	1.5	3.0	1.3	2.6	Dursban	0	0	5	14

Table 5. Adult Corn Rootworm Control Using Carbaryl 4-Oil, Carroll County, 1976-1977

Treatment	Root ratings				
	Welp	P. Warner	W. Warner	Meador	S. Smith
Sprayed with carbaryl 4-oil 1976; no soil insecticide in 1977	1.70	1.75	1.75	2.85	1.80
Sprayed with carbaryl 4-oil 1976; plus soil insecticide (Counter) in 1977	1.35	1.35	1.10	1.70	1.30

Table 6. Adult Rootworm Control Using Carbaryl 4-Oil, Wayland Farm, McDonough County, 1976-1977

Field No.	Date sprayed	Root ratings in 1977	
		Carbaryl 4-oil 1976; plus soil insecticide in 1977	Carbaryl 4-oil 1976; no soil insecticide in 1977
2-1	8/3, 8/18	2.0	2.3
2-2	8/3, 8/18	2.0	2.4
2-3	8/3	2.1	2.7
2-4	8/3	2.0	3.5
6-5	8/3, 8/18	2.0	3.0

CORN ROOTWORMS AND THEIR CONTROL IN ILLINOIS

D.E. Kuhlman, J.L. Wedberg

How serious will corn rootworms be in 1978? If the abundance of northern and western corn rootworms beetles last July and August is any kind of an indicator, corn growers in the northern two-thirds of Illinois need to have their guard up in 1978. There is no escaping the fact that rootworm beetle populations last summer were the highest observed in Illinois since the first survey was taken in 1966 (see "Insect Situation and Outlook and Insecticide Usage" by Wedberg and Black).

In counties north of Route 36, a potential for moderate to severe damage by rootworm larvae exists in virtually all fields of corn that follow corn. About 20 percent of the cornfields south of Route 36 and north of Route 50 (St. Louis to Lawrenceville) have a potential for rootworm damage if replanted to corn in 1978; the potential for rootworm damage in continuous corn south of Route 50 is relatively low.

Reasons for High Rootworm Beetle Populations

This dramatic increase in corn rootworm beetle populations in 1976 and 1977 was probably due to a combination of interacting factors. We believe the most important factors contributing to the increase in rootworm beetles are earlier planting, too dry weather, too wet weather, low insecticide rates, and more acres of continuous corn. Rootworm resistance to the organic phosphate and carbamate insecticides has been suspected, but this has not been conclusively demonstrated in laboratory research.

Climatic conditions favorable to rootworms and unfavorable to soil insecticide performance are responsible for some of the increase. For example, heavy rains shortly after planting hastened the decomposition of the soil insecticides in some areas. Lack of rainfall during May and June may have prevented the activation and movement of the insecticide from the soil surface to the root zone where rootworm larvae were feeding. Favorable weather brought about early planting in 1976 and 1977. Soil insecticides applied in early to mid-April lose some of their potency by the time rootworm eggs are hatching in late May and June. Since egg-hatch occurs over four to eight weeks, late-hatching larvae are not controlled by the insecticide, resulting in high survival and ultimately high beetle numbers. Alkaline soils (pH over 7.0) will hasten the degradation of the organic phosphate and carbamate insecticides.

Soil insecticides applied at less than the labeled rate due to "rusted in" applicators or to "cost shaving" will also result in poor or marginal control of rootworms.

Suggestions for Corn Rootworm Control, 1978

In getting ready for the 1978 growing season, corn producers have important decisions to make regarding insect control, weed control, diseases, variety, tillage, fertilizer, planting date, and a multitude of other things. High priority and careful consideration should be given to the selection of a rootworm control program for 1978. The most effective tools currently available to suppress or control corn rootworms are crop rotation and soil insecticides. The final selection is a voluntary action that only the grower can make. We encourage growers to examine the alternatives listed below, then choose the one that best fits their situation.

1. Crop Rotation

This is the most effective method of preventing rootworm damage and should be given serious consideration by growers in 1978. If feasible, do not grow corn two years in succession in the same field. Crop rotation may not be economically feasible for all corn producers or on all land producing corn, but this practice in select fields will reduce the number of rootworms and enhance control of this pest with our contemporary insecticides.

Fields of corn planted in late May or June, 1977, or fields that averaged more than 5 rootworm beetles per plant in July and August are good candidates for a crop other than corn in 1978. Late-planted fields of corn very likely attracted high numbers of rootworm beetles from adjacent fields during August, 1977, seeking pollen and silks to feed upon. They may have laid millions of eggs in these late-planted fields. Consequently, diverting these fields to another crop in 1978 will contribute toward reducing overall rootworm populations.

Many growers have expressed concern about the potential for rootworm damage to corn following soybeans. High numbers of beetles were observed in soybeans last summer, leading to speculation that the beetles are depositing eggs in bean fields. Only on rare occasions has economic damage from rootworms occurred on corn following soybeans. All research to date indicates that corn following soybeans is unlikely to have rootworm damage, and consequently would not need to be treated with a soil insecticide. An exception might be when corn is planted after soybeans in which there was an extensive infestation of volunteer corn or weeds in the soybeans during August.

Soybeans, grain and forage sorghum, small grains, and legumes such as alfalfa and red clover could be used in rotations. The larvae hatching from rootworm eggs cannot survive on the roots of broadleaf weeds or crops such as soybeans, small grains, alfalfa, or sorghum. Thus when a crop other than corn is planted in a field with soil containing millions of rootworm eggs, literally millions of larvae will perish and not emerge as egg-laying beetles.

2. Planting Date

If planting before April 15, consider putting the rootworm insecticide on during cultivation in May. We are concerned that planting-time treatments in early April may not give effective rootworm control, particularly if rainfall is excessive and the bulk of the egg-hatch does not commence until June. Plant last those fields that had high populations of rootworm beetles. The breakdown of the soil insecticide will be less with late planting (mid-May) than with early planting (early April).

3. Variety

There are no truly resistant or tolerant hybrids for rootworms available to growers. Select those varieties that have good standability and the ability to recover from root-pruning.

4. Soil Insecticides-Planter Applications

The soil insecticides suggested for planting time are Counter, Dyfonate, Furadan, Lorsban, MoCap, and Thimet (Table 1). Apply these treatments as a 7-inch band ahead of the press wheel at 1 pound of active ingredient per acre, based on 40-inch rows. Counter and Furadan are also labeled for in-furrow placement, but band applications are generally more effective.

Table 1. Soil Insecticides Suggested for Corn Rootworm Control at Planting, 1978

Insecticide	Class	Ounces of product per 1,000 ft. of row	Pounds of product needed per acre			
			40" rows	38" rows	36" rows	30" rows
Counter 15G	Organic phosphate	8	6.7	7.0	7.4	8.7
Dyfonate 20G	Organic phosphate	6	5.0	5.3	5.6	6.7
Furadan 10G	Carbamate	12	10.0	10.5	11.1	13.3
Lorsban 15G	Organic phosphate	8	6.7	7.0	7.4	8.7
Mocap 10G	Organic phosphate	12	10.0	10.5	11.1	13.3
Thimet 15G	Organic phosphate	8	6.7	7.0	7.4	8.7

Planter treatments in early April may give marginal control. Consider making a mid- to late May cultivator application in these early-planted fields, rather than a planting-time treatment.

We want to stress that none of the rootworm soil insecticides will give 100-percent control of the larvae. High beetle numbers in fields last summer may have left the impression that rootworm control was poor; but if the plants were standing and well-rooted, control was probably adequate.

Last year we suggested that growers consider switching classes of soil insecticides, particularly if an insecticide had been used for several consecutive years in the same field and was giving poor control. This principle holds true for 1978. *If a soil insecticide gave fair to good control in 1977, it will probably do an adequate job in 1978. If the insecticide gave poor control in 1977, switch to another insecticide in 1978.*

Research conducted in 1976 and 1977 indicates that switching from a carbamate (Furadan) to an organic phosphate (Counter, Dyfonate, Lorsban, Mocap, or Thimet) may be necessary in some instances. In fields with a history of Furadan use, rootworm control with Furadan was marginal in five of seventeen tests. In fields with a history of two or more consecutive years of organic phosphate use, rootworm control with a carbamate (Furadan) was equal to or slightly better than control with the organic phosphates in eleven of eleven tests.

Consequently, if control with Furadan was marginal or poor in 1977, switch to an organic phosphate (Counter, Dyfonate, Lorsban, Mocap, or Thimet) in 1978. In fields where Furadan failures have occurred, it may be advisable to wait more than one season before using it again. If control with an organic phosphate was poor last year, switch to a carbamate.

A word of caution about switching classes of soil insecticides. In a few instances last year, switching insecticides did not give good results. The performance of an insecticide that gives only fair control of rootworms will not be improved by rotation with other insecticides. Performance might be enhanced under favorable weather conditions or with light infestations.

Some growers have expressed a desire to broadcast a liquid rootworm insecticide rather than to apply granular materials in a band ahead of the press wheel. Broadcast applications of liquid and granular insecticides are not legally labeled for the control of corn rootworms. Liquid formulations of Furadan 4F or Dyfonate 4E may be mixed with water and applied as a spray in a 7-inch band ahead of the press wheel, or mixed with liquid fertilizer and applied with a split-boot applicator. Some farmers experienced compatibility problems or crop injury problems with liquid insecticides-fertilizer treatments in 1977. The liquid insecticide *must* be compatible with the liquid fertilizer. Test to make certain the mixture is physically compatible *before* planting. Use caution when handling liquid formulations. They are more toxic than granular formulations.

5. Cultivator Treatments

The best time to apply a soil insecticide by cultivator is in late May, near the time of egg-hatch. Such a treatment may be more effective than planting-time treatments in early April. Apply granular Dyfonate, Furadan, Mocap or Thimet in a band at the base of plants just ahead of the cultivator shovels and cover the granules with soil.

Cultivator applications of rootworm soil insecticides have some limitations. If rainfall is low for three or four weeks after the cultivator treatment, the insecticide granules will remain near the soil surface rather than moving down to where the larvae are feeding, and control will be marginal. If there is excess rainfall, it may not be possible to apply the cultivator application at the desired time.

6. Rootworm Beetle Suppression

There is considerable interest in the use of aerial sprays of Sevin 4-oil to kill rootworm beetles in July or August with the intent of reducing or eliminating larvae damage to next year's crop.

Midwest researchers to date have had variable success in aerially applying Sevin 4-oil and other insecticides to kill rootworm beetles and eliminate the need for soil treatment the following year. The theory of killing rootworm beetles before they deposit eggs in a field is good. In practice, applications of Sevin 4-oil and other insecticides applied in July or August to kill rootworm beetles are not always effective in reducing or eliminating next year's larval infestation. We estimate this approach has been successful in about 50 percent of the research tests conducted in the Corn Belt. In general, the soil insecticide alone has been as effective as a beetle-suppression program plus a soil treatment the following spring.

At present, we will suggest the use of insecticides only to control rootworm beetles where pollination damage due to silk clipping may occur.

The chief limitations to the effectiveness of the adult-suppression program are proper timing and longevity of the insecticide. The treatment must be applied early enough to kill early-emerging beetles before they lay eggs, and the residual activity of the insecticide must be enough to control late-emerging beetles. This means the residual activity of the insecticide must keep rootworm beetle populations below the economic threshold of one-half beetle per plant for a period of four to six weeks, or roughly mid-July to late August, depending on the growing season. Thus far, the insecticides have not been this effective.

Rootworm Control Research Results, 1977

Tests to evaluate the efficacy of various corn rootworm soil insecticides were conducted in Bureau, Carroll, Ford, Kane, McDonough, Ogle, Stephenson, Tazewell, and Whiteside Counties during 1977. The primary objective was to determine whether it is advantageous to alternate annually between organic phosphate and carbamate soil insecticides, depending on the previous insecticide that was used in a field. The tests were conducted in four fields with a history of organic phosphate insecticide use, six with a history of carbamate use, and six where growers had been alternating classes of soil insecticides. All the fields had high populations of northern and western corn rootworm beetles during July and August of 1976.

We wish to express our thanks and sincere appreciation to the following county Extension advisers and growers for their assistance and cooperation in these tests.

Bureau County: J. F. Ellis, Extension adviser, Princeton; Don and Robert Kenney, Tiskilwa; Phil Naffziger, Walnut; Charles Read, Princeton.
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McDonough County: R. D. Weller, Extension adviser, Macomb; and Paul Wayland, Macomb.
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Materials and Methods

The soil insecticides evaluated in these tests were carbofuran (Furadan 10G), fonofos (Dyfonate 20G, 10GK, and 15GK), ethoprop (Mocap 10G), terbufos (Counter 15G), phorate (Thimet 15G), chlorpyrifos (Lorsban 15G), bufencarb (Bux 10G), and CGA 12223. The granular insecticides were applied in a 7-inch band, using a one-row Noble applicator mounted on bicycle wheels. The granules were incorporated with a rake.

The application rate for each insecticide was 1 pound of active ingredient per acre, based on 40-inch rows. Each treatment was replicated four times in a randomized complete block design. The plots were 50 feet long and one row wide. The dates of the planting-time treatments are shown in Tables 2 to 4 for each location.

The cultivator treatments were applied on June 2 or 3, using the same applicator as for the planting-time treatments. The granules were directed to the base of the plant and incorporated with a rake.

The performance of the various soil insecticides in controlling corn rootworms was evaluated July 5-13. The root systems of five plants from each replicate were examined and rated for damage using a "root rating" system of 1 to 6:

1 = No visible damage, or only a few minor feeding scars.

2 = Some roots with feeding scars, but none eaten off within 1.5 inches of the plant.

3 = Several roots eaten off to within 1.5 inches of the plant, but never the equivalent of an entire node of roots gone.

4 = One node of roots destroyed, or the equivalent.

5 = Two nodes of roots destroyed.

6 = Three or more nodes destroyed.

Results

The results of rootworm control in 16 tests where there were economic infestations are shown in Tables 2, 3, 4, 5, and 6. The root ratings in the untreated plots of these fields averaged 3.0 or more. Damage in other fields was too light for comparison and is not included in these data.

Based on root-rating averages for 16 fields, Counter and Furadan gave the most consistent control of rootworms, followed by Mocap, Thimet, Dyfonate, and Lorsban (Table 2).

These insecticides are likely to give acceptable commercial control of rootworms under most field conditions. The exceptions would be where heavy infestations occur. In these fields, it would be well to use a rootworm insecticide that ranks near the top in consistency and performance. For further comparison we have ranked the effectiveness of rootworm control using three criteria: (1) number of tests where rootworm control was not significantly different from the untreated; (2) number of tests where rootworm control was not significantly different from the best treatment; and (3) number of tests where the soil insecticide gave effective control. These comparisons (Table 3) indicate that Counter and Furadan gave the most consistent control of corn rootworms; Dyfonate, Mocap, and Thimet were next in consistency, followed by Lorsban.

Following is a discussion of insecticide performance in controlling rootworms based on the insecticide history of the field. A root rating of 3 or less was considered to be satisfactory performance by an insecticide.

Carbamate History

In fields with a history of Furadan use, rootworm control with Furadan was satisfactory in five of six tests (Table 4). Control with Furadan was marginal in the Birkey field. Over the past two years, rootworm control with Furadan in fields with a history of Furadan use was marginal in five of seventeen tests.

Organic Phosphate History

The infestations in fields where organic phosphate soil insecticides had been used for two or more consecutive years were relatively light in 1977. Rootworm control with a carbamate (Furadan) was equal to or slightly better than control with the organic phosphates in four of four tests (Table 5). In two years of tests, Furadan was equal to or better than the organic phosphates in eleven of eleven tests. Previous use of an organic phosphate insecticide in a field does not appear to influence the performance of the organic phosphates to any great extent.

In most tests, the organic phosphates gave fair to good rootworm control, even where they had been used previously for several years.

History of Alternating Classes of Insecticides

Tests were conducted in six fields during 1977 in which control with Furadan was marginal or poor in 1975. The growers switched to an organic phosphate in 1976. In 1977, rootworm control with Furadan was good in three of the fields and marginal (but adequate) in three fields (Table 6). In these same fields during 1976, rootworm control with Furadan was marginal to poor in five of the six fields. These data suggest that in fields where a true Furadan failure has occurred, it is advisable to wait more than one year before using it again.

Table 2. Corn Rootworm Control in 16 Fields, Illinois, 1977

Treatment	Lb. a.i./a.	Placement	Average Root Rating
Counter 15G	1	7" band	2.23
Furadan 10G	1	7" band	2.34
Mocap 10G	1	7" band	2.45
Thimet 15G	1	7" band	2.46
Dyfonate 20G	1	7" band	2.52
Lorsban	1	7" band	2.74
Check	..	..	3.86

Table 3. Rootworm Control, Illinois, 1977

Treatment	Lb. a.i./a.	Number of tests where rootworm control was not significantly different from the untreated	Number of tests where rootworm control was not significantly different from the best treatment	Number of tests where the soil insecticide treatment gave effective control[a]
Counter 15G	1	0 in 16	14 in 16	15 in 16
Furadan 10G	1	1 in 16	13 in 16	14 in 16
Dyfonate 20G	1	2 in 16	11 in 16	13 in 16
Mocap 10G	1	2 in 16	11 in 16	14 in 16
Thimet 15G	1	0 in 16	11 in 16	13 in 16
Lorsban 15G	1	3 in 16	6 in 16	10 in 16

[a]Root pruning of the treatment was not enough to cause a yield loss (based on root rating of 3.0 or less).

Table 4. Corn Rootworm Control in Fields With a History of Carbamate Insecticide Use, Illinois, 1977

Treatment	Lb. a.i./a.	Placement	Mean root rating[a] Lewis	Birkey	Read-W	Punke	Dollmeyer	Kenny-S	Average
Counter 15G	1	7" band	2.10 a	2.0 a	2.15 a	2.10 ab	2.0 b	2.45 ab	2.13
Mocap 10G	1	7" band	2.05 a	2.25 ab	2.35 ab	2.1 ab	2.1 b	2.6 ab	2.24
Thimet 15G	1	7" band	2.45 a	2.05 a	2.55 ab	2.0 a	2.2 b	2.65 ab	2.32
Furadan 10G	1	7" band	2.20 a	3.4 c	2.55 ab	2.0 a	1.8 ab	1.95 a	2.32
Dyfonate 20G	1	7" band	2.05 a	2.15 ab	2.25 ab	2.3 ab	2.05 b	3.85 c	2.44
Lorsban 15G	1	7" band	2.35 a	2.4 ab	2.25 ab	2.4 b	2.15 b	3.5 bc	2.51
CGA 12223 20G	1	7" band	2.0 a	2.0 a	..	..	1.4 a	..	..
Furadan 10G	2	7" band	2.1 a	..	..	..	..	..	..
Counter 15G	2	7" band	2.1 a	..	..	..	..	..	..
Furadan 10G	1	Band-uninc.	2.35 a	..	..	2.0 a	..	..	..
Counter 15G	1	Band-uninc.	2.4 a	..	..	..	..	..	..
Dyfonate 15GK	1	7" band	..	2.25 ab	..	..	..	..	..
Dyfonate 10GK	1	7" band	..	2.55 b	..	..	..	..	..
Dyfonate 20G	1	Cultivator	..	4.15 d	..	..	..	..	..
Furadan 10G	1	Cultivator	..	..	2.9 b	..	..	..	..
Bux 10G	1	7" band	..	2.25 ab	..	..	..	2.75 ab	..
Check	..	..	3.6 b	4.95 e	3.75 c	3.15 c	3.10 c	4.2 c	3.79

Year	Field treatment history					
1976	Furadan	Furadan	Furadan	Furadan	Furadan	Furadan
1975	Furadan	Furadan	Furadan	Furadan	Furadan	Furadan
1974	Furadan	Furadan	Thimet	Soybeans	Furadan	Furadan
1973	Furadan	Furadan	Thimet	..	Furadan	Furadan
Plot in	May 18	April 25	April 29	April 29	May 11	May 4

[a]Root-damage ratings based on a scale of 1 to 6. Treatment means based on 20 observations (5 roots X 4 replications). Means followed by the same letter do not differ significantly at the 5% level according to Duncan's Multiple Range Test.

Table 5. Corn Rootworm Control in Fields With a History of Organic Phosphate Insecticide Use, Illinois, 1977

	Lbs.		Mean root rating[a]				
Treatment	a.i./a.	Placement	Poulter	Naffziger	Kwasigroh	McCannon	Average
Furadan 10G	1	7" band	2.45 abc	2.0 a	2.0 a	1.25 a	1.93
Counter 15G	1	7" band	2.2 ab	2.15 a	2.0 a	1.65 ab	2.0
Thimet 15G	1	7" band	2.1 a	2.05 a	2.1 a	2.05 b	2.08
Mocap 10G	1	7" band	2.7 abc	1.95 a	2.1 a	2.00 b	2.19
Dyfonate 20G	1	7" band	2.85 bc	2.25 a	2.15 ab	2.15 b	2.35
Lorsban 15G	1	7" band	3.00 c	2.2 a	2.65 b	2.25 b	2.53
Counter 15G	1	Cultivator	2.2 ab	..	2.0 a	..	..
Bux 10G	1	7" band	..	..	2.0 a	..	..
Furadan 10G	2	7" band	..	..	2.0 a	..	..
CGA 12223 20G	1	7" band	..	1.8 a	..	2.20 b	..
Check	..	..	3.0 c	3.25 b	3.45 c	2.9 c	3.15

Year	Field treatment history			
1976	Counter	Thimet	Counter	Thimet
1975	Thimet	Thimet	Dyfonate	Thimet
1974	Thimet	Thimet	Dyfonate	Thimet
1973	Thimet	Thimet	Dyfonate	Thimet
Plot in	April 29	May 19	April 28	May 10

[a]Root-damage ratings based on a scale of 1 to 6. Treatment means based on 20 observations (5 roots X 4 replications). Means followed by the same letter do not differ significantly at the 5% level according to Duncan's Multiple Range Test.

Table 6. Corn Rootworm Control in Fields Where Farmers Have Alternated Carbamate and Organo Phosphate Insecticides, Illinois, 1977

Treatment	Lbs. a.i./a.	Placement	Mean root rating[a] Bowen	Myers	D. Larsen	Rackow	Fluegel	Berg	Average
Counter 15G	1	7" band	2.65 ab	1.9 a	4.05 c	2.1 a	1.9 a	2.25 a	2.48
Furadan 10G	1	7" band	2.2 a	2.85 b	2.45 a	3.2 b	2.35 abc	2.75 ab	2.63
Dyfonate 20G	1	7" band	2.85 ab	2.15 ab	3.45 bc	2.25 a	2.45 abc	3.05 abc	2.7
Mocap 10G	1	7" band	2.4 ab	2.5 ab	2.45 a	3.3 b	2.7 c	3.7 cd	2.84
Thimet 15G	1	7" band	3.1 b	2.1 ab	3.9 c	3.1 b	2.3 abc	2.65 ab	2.86
Lorsban 15G	1	7" band	3.0 ab	2.15 ab	3.7 c	3.1 b	2.6 bc	4.1 d	3.11
Furadan 10G	1	Cultivator	2.35 ab	2.8 b	..	..	..	..	..
CGA 12223 20G	1	7" band	..	..	2.8 ab	2.05 a	..	3.2 bc	..
Bux 10G	1	7" band	..	..	..	..	2.05 ab	..	..
Check	..	..	4.5 c	3.9 c	5.25 d	4.35 c	4.1 d	4.3 d	4.4

Year	Field treatment history					
1976	Counter	Counter	Counter	Counter	Counter	Thimet
1975	Furadan	Furadan	Furadan	Furadan	Furadan	Furadan
1974	Furadan	Furadan	Furadan	Furadan	Furadan	Furadan
1973	..	Furadan	Furadan	Oats	Furadan	Furadan
Plot in	May 11	May 11	May 19	May 7	May 7	May 7

[a]Root-damage ratings based on a scale of 1 to 6. Treatment means based on 20 observations (5 roots X 4 replications). Means followed by the same letter do not differ significantly at the 5% level according to Duncan's Multiple Range Test.

INSECT SITUATION AND OUTLOOK AND INSECTICIDE USAGE

J.L. Wedberg, K.D. Black

Highlights

Western and northern corn rootworms rate the "Insect Problem of the Year Award" for the second consecutive year. Beetle populations observed during our August survey have never been higher. Fortunately, most of the corn had finished pollinating before peak beetle emergence. Only 768,140 acres were sprayed to prevent silk clipping, compared with 1,104,600 acres in 1976 when peak beetle emergence and silking closely coincided (Table 1).

The two-spotted mite was less of a problem in 1977 than in 1976. However, if we again have dry weather during the growing season, this and other dry-weather pests, such as grasshoppers and chinch bugs, will have to be watched.

With the exception of green cloverworms in soybeans, we had very few widespread problems during 1977. More problems lingered late into the season than normal. Reports of bean leaf beetles in late-planted soybeans and fall armyworms in alfalfa, pasture, and rye were common.

County Extension advisers in agriculture answered insecticide-use questionnaires covering the use and methods of insecticide application in their counties (Tables 1 through 4). The most common insect pest problems reported by advisers during 1977, in order of importance for agricultural and nonagricultural areas, are as follows:

Agricultural	Nonagricultural
1. Corn Rootworms	1. Garden Insects
2. Green Cloverworms	2. Termites
3. Black Cutworms	3. Cockroaches
4. Alfalfa Weevils	4. Aphids
5. Grasshoppers	5. Ants
6. European Corn Borers	6. Mosquitoes
7. Fall Armyworms	7. Cereal Insects
8. Potato Leafhoppers	8. White Grubs
9. Bean Leaf Beetles	9. Spiders
10. Stored-Grain Insects	10. Flies

Dollar Savings Due to Insecticides

An estimated 8,577,090 acres of Illinois field crops were treated with insecticides during 1977 (Table 1). It is estimated that a return of $29,372,930 over and above treatment costs was realized from control of soil insects (based on yield increase from use of rootworm insecticides). The increase in the number of acres treated with a soil insecticide (6,572,910 acres in 1977 against 6,364,420 acres in 1976) is a reflection of the increased corn acreage and spreading concern over corn rootworms. It is estimated that the diazinon planter-box seed treatment was used on an additional 1,938,000 acres. County Extension advisers reported increases in mechanical difficulties with the use of the seed treatment. The treatment is blown off the seed and does not readily feed through the air-type planters. It can build up in plateless planters and has been known to foul electronic seed monitors. The percentage of areas treated by aerial and ground applicators and by individual farmers is given in Tables 2 and 3. Trends in insecticide usage are given in Table 4. Note the marked decline in use of chlorinated hydrocarbons.

Corn Insects

Corn Rootworms. The abundance of rootworm beetles in a cornfield is an indication of the potential for larval damage the following year if the field is again planted to corn. Most eggs are deposited during August, and the potential for egg-laying is usually greater in fields with high numbers of adults during mid- to late summer. Larvae will hatch from these eggs and attack corn roots the following May.

Results of our August, 1977, beetle survey are given in Table 5. Populations of northern and western corn rootworm beetles were even higher than those observed during 1976, our previous all-time high. Because of this, the potential for larval damage in 1978 is serious. Moderate to severe damage is expected in many fields of corn that follow corn in the area north of a line from Belleville to Lawrenceville (Figure 1). Damage potential south of this line is low.

The western corn rootworm has now been found in 85 Illinois counties. Fifteen new counties were added to this list during 1977 (Figure 2). Table 6 shows the species composition (northern and western) of beetle surveys conducted during August.

European Corn Borers. Although the 1976-77 overwintering (second-generation) borer population was one of the lowest in recent years, populations increased during the summer of 1977 and resulted in extremely high second-generation numbers over most of the state in the fall (Tables 7, 8, 9). An estimated 79,440 acres of corn were sprayed for borers during 1977 with an estimated return of $635,200 over and above treatment cost. Results of our fall European corn borer survey are given in Table 8. The overwintering population of 1977-78 was 155 borers per 100 plants as opposed to only 32 per 100 plants for 1976-77. In general, the greater the fall population the greater the potential for damage by first-generation borers the following spring. Because of this, the potential for damage by first-generation borers during the spring of 1978 is the highest in recent years (Figure 3). The potential for damage is greatest in the west and southwest districts.

European corn borers pass the winter in Illinois as full-grown larvae in corn stalks and debris and weed stems. Spring development commences when temperatures exceed 50°F. Development normally begins during early May in southern Illinois and during late May in northern sections. Unseasonably warm spring weather during 1977 allowed development to begin approximately two weeks ahead of expectations.

Moths begin to emerge in late May. Females lay most of their eggs in the evening, while daylight hours are spent in fence rows and other protected areas. The earliest planted cornfields are most attractive to these moths for egg-laying. The eggs, laid in masses with eggs overlapping like shingles, are usually deposited near the midrib on the undersides of corn leaves.

Larval survival and damage is greatest in tall corn. Most of the first-generation larvae pupate during summer. First-generation moths emerge from these pupae and seek out the greenest, most succulent corn for egg-laying. Larvae hatched from these eggs comprise the second generation. Because of the early spring, southern Illinois experienced a complete third-generation of European corn borers during 1977 while many of the more northern counties had a partial third generation. In addition to corn, these borers attacked edible beans. Some fields were abandoned for production purposes because of excessive damage.

High humidity is favorable for egg deposition by moths and favors egg survival by reducing losses due to dessication. High humidity also favors survival of larvae. Conversely, high temperature and low humidity increase the possibility of dessication and can lower survival of all forms. Alternate rolling and unrolling of corn leaves during drouth can dislodge egg masses from the plant.

Early planting of corn in 1977 was an important factor in accounting for the build-up of corn borers from a low overwintering population. By May 2, 1977, 45 percent of the corn in the state was planted, compared with the three-year average of 21 percent (Illinois Cooperative Crop Reporting Service). This resulted in corn plant maturity favorable for borer survival over a wide area.

First-generation borers reduce potential yield by leaf-feeding, which results in loss of leaf tissue, and stalk-tunneling, which weakens the plant and destroys food-transporting tissue. It is generally accepted that tunneling activity makes the plant susceptible to various stalk rots. Since moths from overwintering borers are attracted to the tallest corn, carefully monitor early-planted fields for damage by first-generation borers during early June, 1978. Control measures may be warranted if 50 percent or more of the plants have fresh whorl-feeding. To determine the need for treatment, measure from the bottom of the plant to the tip of the longest leaf. Split the plant and find the developing tassel. Measure from the bottom of the plant to the tip of the developing tassel. Divide the tassel height by the plant height and multiply by 100. The field should be treated if the tassel ratio is 30 or more and if 50 percent or more of the plants have fresh corn borer feeding in the whorl. If damage is confined to the older leaves and none can be found in the furled leaves within the whorl, the larvae have probably bored into the stalks and it is too late to use insecticides. Corn borer larvae have six stages of growth. Early stages feed on the surface of leaf tissue. However, in approximately their fourth stage of larval development, they become "borers" and tunnel into mid-veins and stalks.

Although there is some evidence that stalk tunneling by second-generation European corn borers can reduce yield potential in a manner similar to first-brood borers, the greatest threat to corn production is an actual yield loss through dropped ears (caused by shank-tunneling) and breakage of stalks weakened by borer tunneling. Damage by the third generation is identical to damage by the second. Second- and third-generation borers also damage the ear by feeding on cobs, silks, and kernels. This activity is very important to producers of canning and fresh-market sweet corn.

When planted early, long-season hybrids are prone to attack by first-generation borers but may still be attractive to second-generation borers.

A continuous trend toward reduced tillage systems that do not destroy corn stubble will enhance survival of overwintering borers and increase the potential for attack by first-generation borers.

Late-planted corn is most attractive to moths laying eggs for the second generation. Since the moths emerge and lay eggs over a long period of time, development of treatment thresholds and timing of insecticide applications are difficult. Often, the first indication of problems that the grower observes is broken stalks in the fall. At this stage the only possible recommendation is to harvest as early as possible to reduce harvest losses.

Hybrids with varying degrees of resistance to leaf feeding by first-generation borers are available. Growers should consider this trait when selecting varieties for planting during 1978. In many cases the resistance agent is a product known as DIMBOA. However, as the plant matures, DIMBOA levels change and plants are no longer resistant when second- and third-generation borers are present.

Black Cutworms. An estimated 52,228 acres of corn had to be replanted and 69,110 received emergency treatment. It is estimated that this returned $276,440 above treatment costs.

As corn plants emerge during 1978, frequent observations should be made for signs of cut, wilting, or missing plants. In general, the heaviest infestations have occurred in fields with considerable surface debris from the preceding crop or weeds. If you find damage, dig around the base of plants to find worms. If you find 2 or more worms per 100 plants, or if 3 percent or more of the plants have been cut and worms are present, make plans to treat at once before the damage becomes greater. When cutworms are approximately 1 inch long, they will feed for another 10 to 12 days if temperatures average 70° or higher.

Chinch Bugs. This insect was more common during 1977 than in previous years. Although almost no fields needed treatment, problems were relatively common in more western states. Dry summer weather during 1978 will increase the potential for chinch bug problems in 1978.

Chinch bugs overwinter as adults in hedge rows, bushes and grassy areas, fence rows, and other sheltered locations. When available, they seem to prefer clump-forming prairie grasses.

They will climb up on grasses and other plants in the spring and fly to small grains. Eggs are laid behind the boot of lower leaves or on roots if the soil is loose. Young hatched from these eggs suck juices from the plants. As the grain ripens and dries out, the nymphs are forced to migrate to corn, sorghum, or other grasses. Since they are wingless, they migrate on foot. Watch corn and sorghum adjacent to wheat fields during 1978.

Eggs of the second generation are deposited in corn, sorghum, and other grasses. A full generation develops here before migration to overwintering sites in the fall.

If spraying of row crops is necessary during 1978, directed sprays and high rates of water per acre will give better results than broadcast applications. If problem fields are adjacent to small grains, spraying the stubble for several rounds will help reduce migration.

Southwestern Corn Borers. Borers were found in four new counties during our fall survey of 1977: Wabash, Edwards, Wayne, and Jefferson (Figure 4). This is the first extension of this pest's range in Illinois since 1969.

If the southwestern corn borer overwinters in Illinois at all, it does so in very low numbers. So far, we have been unable to find larvae surviving in stubble in the early spring.

Fall Armyworms. Problems were more common in late-planted corn than during 1976. During 1976, 20,150 acres were sprayed compared with 27,600 acres in 1977. Although not widespread, populations and damage were severe in localized areas. Some fields of double-cropped corn were almost 100 percent infested.

These brown-to-dull-green, smooth-skinned worms feed in the whorl and give the plants a ragged appearance as leaves unfurl. Damage in fields is spotty, with a series of plants in a row showing injury.

In most instances, damaged plants recover and are difficult to identify at harvest. However, feeding injury creates stress for a plant, and control is recommended if 20 percent or more of the plants are infested and if worms are still present. You will have to pull whorl leaves and unroll them to determine if worms are still present.

Granular formulations are more effective than sprays, particularly if worms are feeding deep in the whorl.

Grasshoppers. During 1977, 47,930 acres of corn were treated, compared with 3,790 acres during 1976. If we experience dry weather during egg hatch this spring, grasshopper population will probably remain high during 1978. Almost all of the species that attack corn and soybeans overwinter in the egg stage. Eggs are laid in clusters from 1/2 to 2 inches below the surface of the soil. They are primarily deposited in uncultivated ground such as field margins, roadsides, and fence rows. Hatching usually begins in mid-May and continues until July. Heavy rains and prolonged wet spells during egg hatch are detrimental to the young hoppers.

The best time to spray for grasshoppers is when they are abundant in fence rows, ditchbanks, roadsides, hayfields, pastures, etc., before they move into row crops. Small grasshoppers (nymphs) are easier to kill with insecticide than are the adults.

The potential for damaging populations of grasshoppers in 1978 is greatest in the northeast, west-southwest, east-southeast, southwest, and southeast districts (Figure 6).

Soybean Insects

Green Cloverworms. An estimated 336,000 acres of soybeans were sprayed for green cloverworm during 1977 compared with 735,917 acres during the outbreak of 1973. Populations reached near-damaging levels in early July; a few fields needed spraying. However, a second peak occurred in mid-August and this accounted for the majority of the sprayed acres. We have several generations of green cloverworms each year. The earliest generations occur in clover and alfalfa fields. Moths of later generations lay eggs in soybeans. This normally occurs in July and August.

An outbreak of this insect one year does not necessarily mean an outbreak will occur the following year. The outbreak of 1973 was followed by three years of low incidence of this pest. Numerous pathogens, parasites, and predators are known to attack the cloverworm. One of the most effective agents in reducing green cloverworm populations is the fungal disease *Nomurea rileyi*. When weather conditions are right, spores of this fungus spread to the larvae, germinate, and penetrate the body wall. Infected larvae are sluggish and soon die. Shortly after death, the entire body becomes hard and mummylike as the fungus grows throughout the host. Initially, the cadaver is covered by a whitish layer of fungal stands. High humidity favors the spread of this disease. Closure of the soybean canopy during late season probably produces a microclimate suitable for development of the fungus.

Despite the abundant presence of infected larvae in late-season cloverworms, the fungi are almost nonexistent in early-season generations. This indicates poor survival of the fungi during the winter.

Two species of parasitic wasps, *Apantales marginiventris* and *Rogus nolophanae*, and parasitic flies (family Tachinidae) also help to lower populations of green cloverworms in Illinois. Larvae parasitized by the wasps are found on leaves as small, mummified, spindle-shaped objects. The parasitic flies lay small, globular white eggs behind the head of the cloverworm.

To check the situation in a field, spread a newspaper or dropcloth between two rows. Bend the plants toward the middle of the row and shake them vigorously over the paper or cloth. Count the worms dislodged from the plant. To justify treatment, there should be 12 or more half-grown worms (approximately 1/2 to 3/4 inch long or longer) per linear foot of row and 15 percent defoliation in the pod set and fill stage. Note the size, degree of parasitism, and presence of dead white worms. It may not be necessary to spray.

Bean Leaf Beetles. This beetle was primarily a problem in double-cropped soybeans. Bean leaf beetles overwinter as adults, and early-planted soybeans are very important to survival of colonizing adults in the spring. The size of populations later in the summer is related to this success. The early spring and early planting of soybeans probably contributed to problems with this insect during August. Since they emerge before soybeans are planted, and quickly move to the earliest planted fields, populations tend to reach higher levels in these fields. In instances where the number of overwintering adults is high, damage to seedlings can be extensive. However, damage is usually greatest in August and September.

Bean leaf beetles prefer the youngest plant tissue available; when vegetative growth terminates, they will consume tender pod tissue.

Mites. The two-spotted mite was again a problem during 1977, particularly in the drouth-stricken western areas of the state. Hot, dry weather allows the mite to reach epidemic proportions. The mite is nearly microscopic in size, and its injury symptoms closely resemble injuries due to drouth. Mite-infested plants are stunted. Leaves are mottled yellow; under heavy infestations leaves will die, turn brown, and fall to the ground. Prolonged, heavy infestations will kill plants.

Mite injury usually starts along field margins. This is because of the migration of mites out of adjacent clover, grasses, weeds, and so on. During the 1976 outbreak, we found numerous exceptions to the "border effect" in that some infestations appeared to begin in the middle of the field. This probably resulted from mites being blown around by the wind.

If a field of soybeans exhibits the typical symptoms of mite injury during 1978, carefully examine the undersides of several leaves. Look for the fine webbing that is characteristically associated with these mites. The mites are eight-legged, insectlike animals and are so small that they will appear as tiny, black, slow-moving specks on the undersides of leaves. It takes a good magnifying glass or a microscope to see the mites clearly. Many people do not have access to those tools. Another way of checking for the mites is to place a large sheet of white paper on the ground, sharply tap some plants against your hand, and then watch for the moving black specks on the paper.

Since infestation typically begins along the margins of soybean fields, these areas should be watched more carefully. If an infestation begins in this area, a grower can afford to frequently check it for a few days before deciding to spray. Infestations will often be confined to the outer few rows, and in these cases spraying is usually not needed. However, if it appears that the infestation is starting to spread, the infested area should be sprayed immediately. It is advisable to spray several additional rows to serve as a buffer zone.

From past experience we know that chemical control of mites in soybeans has been erratic. The primary problem is coverage; mites are on the undersides of leaves and it is difficult to get sprays to them. Because of the size of the beans, most sprays have to be applied by air, making proper coverage difficult.

Grasshoppers. The increase in grasshopper populations is reflected in 63,920 acres sprayed in 1977 compared with 6,670 acres sprayed in 1976. The potential for damage by grasshoppers in 1978 is greatest in the northeast, west-southwest, east-southeast, southwest, and southeast districts (Figure 5). The biology and control of these pests are discussed in the section covering corn insects.

Blister Beetles. Several species occur in Illinois (striped, black, margined, etc.). Females lay their eggs in the soil, and larvae hatched from these eggs prey upon grasshopper eggs. Prevalence of blister beetles therefore tends to be governed by the abundance of grasshoppers. Because of the high grasshopper populations in some sections of Illinois, we expect to see an increase in blister beetle population over the next couple of years.

Adults will attack potatoes, tomatoes, eggplants, soybeans, alfalfa, and other crops and weeds. They rarely cause economic damage. Often their numbers are great enough to cause some alarm. They will often feed on weeds in cultivated crops and not attack the crops.

Whiteflies. We received a few calls about whiteflies in soybeans during 1977. The species involved were the bandedwing whitefly, *Trialeurodes abutilonea*, and the greenhouse whitefly, *Trialeurodes vaporariorum*. This is nothing new; we have found them during insect surveys in previous years. The number of calls probably reflects increased scouting of soybeans by farmers because of concern over defoliating insects (green cloverworms, etc.). Whiteflies were encountered while searching for other insects. In infested fields observed during our surveys, whitefly populations were always higher on common cocklebur, *Xanthium pensylvanicum*, and velvetleaf, *Abutilon theophrasti*, than on soybeans.

Whiteflies are minute, whitish insects (generally about 1/10 inch) and are in the same insect order as aphids. Like aphids, they have sucking mouthparts and exude honeydew while they feed. Although they are an economic pest in the tropics and in greenhouses, they are not considered to be a pest of soybeans in the Midwest.

Small Grains

Hessian Fly. Populations remained low during 1977, except in the southwest crop reporting district (Table 10, Figure 6). The state average of three puparia (flaxseed) per 100 tillers is greater than the ten-year state average of two puparia per 100 tillers. The southwest district has the highest population. Randolph, St. Clair, and Clinton Counties have populations of 25, 10, and 6 puparia per 100 tillers, respectively. This population level is potentially damaging and could be a source of future problems.

True Armyworm. The incidence of this pest has been very low the past few years, and we are probably overdue for an outbreak.

Wheat Curl Mite. This pest (*Aceria tulipae*) is a vector of wheat streak mosaic virus. The incidence of wheat streak mosaic has been increasing in the southern half of Illinois, particularly where double-cropping of soybeans was practiced and volunteer wheat was present. None of the Illinois wheats is resistant to the virus, and no practical insecticidal or miticidal control agents are available.

Historically, the best control techniques have involved the cultural practices of eliminating volunteer wheat during the summer and observing the Hessian fly-free date for fall-sowing wheat. Destruction of volunteer wheat during the summer by various tillage methods destroys a potential reservoir of mites for fall infestation. Observance of the fly-free date for seeding wheat is beneficial because it helps wheat escape mite migration from other host plants.

The increased incidence of wheat streak mosaic and its probable relation to the increased practice of double-cropping wheat could become a major problem. The situation will be closely watched by Extension entomologists and plant pathologists.

Sorghum Insects

Greenbug. This aphid was more of a problem during 1977 than in previous years. It is estimated that 10,000 acres of sorghum were sprayed. Early maturity of wheat caused by unseasonably warm weather in the spring probably led to massive migration into the more succulent sorghum. Problems were more frequent in fields planted considerably earlier than the recommended agronomic date.

Greenbugs are often confused with the corn leaf aphid. Control of corn leaf aphids on sorghum is rarely justified.

The greenbug is light green or greenish yellow, with a narrow, darker green stripe down the middle of the back. The cornicles (two small tubes at the rear of the body) are green with black tips. The legs are green. The feet are black. Greenbugs usually develop on the underneath side of the leaves.

The blue-green corn leaf aphid is darker than the greenbug and lacks the green stripe down the back. The head is dark. The feet, legs, and cornicles are all black. Colonies usually develop in the whorl and disappear soon after the sorghum head emerges.

Greenbugs suck sap. Their saliva is toxic to plants, causing the tissue to die. Under heavy infestation, the entire plant can be plastered with honeydew and the plant totally discolored. Feeding by greenbug colonies will cause reddish-brown spots that are visible from above. The first evidence of feeding will be yellowing of the plant, followed by browning.

The general recommendation is to spray when greenbugs are present and plants are yellowing during the emergence to 6-inch stage. On larger plants up to pre-boot stage, the recommendation is to spray before any leaves are entirely killed. From pre-boot to hard-dough, spray when it appears that more than two normal-sized leaves will be killed.

There are a number of varieties expressing varying degrees of resistance, and growers are urged to consider this when selecting varieties at planting time. The term resistance is confusing because it is relative and most be determined by comparison with plants that are more severely damaged under the same set of conditions. Greenbugs can be found on resistant grain sorghum, but these varieties can usually tolerate their presence. Make your judgment on the appearance of the plant rather than on the number of aphids alone. If the damage level on "resistant lines" reaches thresholds established for nonresistant lines, it is advisable to treat. Infestations can be found on very young seedlings. Watch the field carefully. Heavy populations on newly-emerged plants can kill the plants quickly.

Fall Armyworm. In the past year, 5,085 acres of grain sorghum were sprayed to control this insect. The majority were double-cropped sorghum. The recommendation is to spray when there are two or more worms per head. Whorl feeding is seldom economic.

Clover and Alfalfa Insects

Alfalfa Weevil. The behavior of this insect was unusual during 1977. Very few eggs were laid during the fall and winter of 1976-77 because of the early onset of cold weather in areas that historically have substantial fall egg deposition. This delayed problems in the spring and the need to spray, and reduced the need for multiple treatment to protect the first crop. An unusually large number of farmers were in situations where they could harvest a little early and spray the stubble. This situation would have been even more widespread if the March hot spell had not occurred. Numerous eggs were deposited during this period and resulted in a large number of larvae appearing suddenly and just before harvest. Prospects for 1978 are given in Figure 7.

Table 1. Acres of Field Crops Treated With Insecticides, Illinois, 1977, Estimated From Reports by County Extension Advisers

Crop and insect	Acres treated
Corn	
Corn flea beetles	67,660
Armyworms	10,380
Corn rootworm adults	768,140
Corn leaf aphids	59,900
Cutworms	69,110
European corn borers	79,440
Grasshoppers	47,930
Soil insects	6,572,910
Fall armyworms	27,600
TOTAL	7,703,070
Soybeans	
Bean leaf beetles	25,820
Mites	49,640
Green cloverworms	336,600
Grasshoppers	63,920
TOTAL	475,980
Wheat	
Armyworms	20,890
Sorghum	
Greenbugs, webworms, fall armyworms, etc.	18,570
Clover, alfalfa, and pastures	
Alfalfa webworms	2,300
Armyworms	8,690
Variegated cutworm	1,330
Alfalfa weevils	220,020
Pea aphids	2,250
Grasshoppers	75,910
Meadow spittlebugs	440
Potato leafhoppers	44,350
Clover leaf weevils	3,290
TOTAL	398,040
1976 TOTAL	8,186,370
1977 TOTAL	8,577,090

Table 2. Percent of Total Field Crops Treated by Commercial and Private Applicators in Illinois, 1965-1977

	Percent of total acreage treated		
	Airplane	Ground application	
Year	application	Commercial	Individual
1965	4.9	10.4	84.3
1966	5.8	13.8	80.4
1967	5.5	14.7	79.8
1968	7.1	13.4	79.5
1969	5.3	15.2	79.5
1970	4.5	16.0	79.5
1971	5.5	13.9	80.6
1972	3.8	15.3	80.9
1973	15.5	19.6	64.9
1974	8.6	18.9	72.5
1975	9.1	18.5	72.4
1976	4.5	16.5	79.0
1977	9.4	11.9	78.6

Table 3. Number of Acres Treated, by Method, for Certain Insects in Illinois, 1977

	Airplane	Ground application	
Insect	application	Commercial	Individual
Green cloverworm	307,450	12,900	16,250
Clover and alfalfa insects	87,710	86,670	99,600
Corn soil insects	124,960	731,320	5,716,630
European corn borer	52,580	17,320	9,540
Grasshoppers	60,620	31,830	95,310
Corn leaf aphid	38,870	11,690	9,340
Sorghum insects	6,690	3,240	8,640
True armyworm	23,950	6,450	9,560
Fall armyworm	14,770	4,430	8,400
TOTAL	717,870	905,850	5,973,270

Table 4. Number of Corn Acres Treated With Different Types of Soil Insecticides, 1968-1977

Year	Chlorinated hydrocarbons	Organic phosphates and carbamates	Total
1968	5,170,726	1,091,143	6,261,869
1969	4,517,931	1,990,138	6,508,069
1970	3,844,740	2,765,547	6,610,287
1971	2,723,119	3,418,920	6,142,039
1972	1,933,089	3,852,239	5,785,328
1973	1,737,510	3,960,543	5,698,053
1974	1,886,042	4,128,300	6,014,342
1975	916,480	4,586,390	5,502,870
1976	935,550	5,428,870	6,364,420
1977	270,520	6,302,390	6,572,910

Table 5. *Northern and Western Corn Rootworm Populations, Illinois, 1972-1977*

District and county	Average number of rootworm beetles per plant[a]					
	1972	1973	1974	1975	1976	1977
Northwest						
Bureau	1.38	1.01	1.07	2.92	3.34	3.63
Lee	.56	.98	.35	.95	2.37	3.55
Mercer	.30	.17	.31	1.06	2.68	2.73
Ogle	.41	.88	.48	.61	5.17	2.49
Stephenson	1.70	1.37	1.95	2.60	4.33	5.62
Whiteside	.83	1.45	.63	1.57	3.00	3.45
AVERAGE	.98	.98	.80	1.62	3.48	3.58
Northeast						
Boone	.44	.40	.23	.49	1.78	3.31
DeKalb	.21	1.05	1.02	.69	1.66	1.94
LaSalle	.43	1.64	.21	1.57	2.44	3.68
AVERAGE	.36	1.03	.48	.92	1.96	2.98
West						
Adams	.26	.06	.06	.04	1.01	1.46
Henderson	1.64	.45	.27	.26	2.05	2.59
Knox	1.11	.24	.68	1.16	3.25	2.32
McDonough	1.13	.13	.29	.06	1.70	1.90
Warren	1.29	.37	.21	1.40	2.48	2.48
AVERAGE	1.09	.25	.30	.58	2.10	2.15
Central						
Logan	.65	.58	1.36	.53	.73	.96
McLean	.46	.93	.71	.15	2.01	2.82
Peoria	.89	.62	.68	1.55	1.65	2.18
Woodford	2.45	.81	1.93	2.84	2.34	2.80
AVERAGE	1.11	.74	1.17	1.27	1.68	2.19
East						
Champaign	2.25	1.86	.67	.33	1.62	1.63
Iroquois	.08	0	.42	.58	.27	2.25
Kankakee	.07	.13	.41	.95	.82	2.80
Livingston	.12	.79	.62	1.14	.96	3.22
Vermilion	0	0	.19	.33	.54	3.22
AVERAGE	.50	.56	.46	.67	.84	2.62
West-southwest						
Christian	.01	.05	0	0	.57	.61
Greene	.06	.23	0	.01	.30	1.50
Macoupin	0	.01	0	0	.23	.77
Montgomery	.05	.06	0	0	.23	.09
AVERAGE	.03	.09	0	.01	.43	.74
East-southeast						
Clark	.01	0	0	0	.01	.19
Jasper	0	0	0	0	.02	.05
Shelby	.35	.10	0	0	.52	.29
AVERAGE	.2	.03	0	0	.18	.18
Southwest						
Randolph	.01	0	0	0	.01	.36
St. Clair	0	0	0	0	0	0
Washington	0	.09	0	0	0	0
AVERAGE	0	.03	0	0	0	.12
Southeast						
Gallatin	0	0	0	0	0	.03
White	.01[b]	.31[b]	0[b]	0[b]	0	0
Wabash	.12	0	0	0	0	0
Wayne[b]	..	..	..	..	..	..
AVERAGE	.04	.10	0	0	0	.01

[a]Counts include both western and northern species. Ten fields were surveyed at random in each county.
[b]Wayne County was substituted for Wabash County in 1976.

Table 6. Composition of Rootworm Beetle Populations, 1967-1977

Year	Number of beetles per 100 plants and WCR percentage[a]	District NW	NE	W	C	E	WSW	ESE	SW	SE	State
1967	Beetles	309	145	121	190	48	20	..	..	0	119
	Pct. WCR	61	0	0	0	0	0	..	..	0	9
1968	Beetles	181	216	116	122	160	18	5	..	12	104
	Pct. WCR	21	0	37	0	0	0	0	..	0	7
1969	Beetles	138	58	60	121	22	17	21	..	..	62
	Pct. WCR	32	0	56	0	0	0	0	..	..	13
1970	Beetles	121	67	12	48	15	0	2	..	26	33
	Pct. WCR	40	7	12	3	0	0	0	..	0	8
1971	Beetles	64	106	64	55	0	0	0	0	0	38
	Pct. WCR	39	22	37	7	3	0	0	0	0	12
1972	Beetles	98	36	109	111	50	7	12	1	4	48
	Pct. WCR	38	36	25	5	7	10	0	0	0	13
1973	Beetles	56	102	25	73	55	11	3	3	10	38
	Pct. WCR	..	..	19	19	3	2	0	0	0	6
1974	Beetles	40	48	30	117	46	0	0	0	0	31
	Pct. WCR	50	34	33	28	46	0	0	0	0	21
1975	Beetles	150	92	48	127	66	1	0	0	0	54
	Pct. WCR	54	30	39	54	37	100	0	0	0	35
1976	Beetles	348	196	210	168	84	43	18	0	0	140
	Pct. WCR	68	58	37	55	50	95	85	..	..	64
1977	Beetles	359	297	215	219	262	73	14	9	.	125
	Pct. WCR	74	66	56	56	76	93	89	0	73	65

[a]Based on random survey of counties.

Table 7. First- and Second-Generation Corn Borer Populations, 1972-1977

District and county	1972 July	1972 Oct.	1973 July	1973 Oct.	1974 July	1974 Oct.	1975 July	1975 Oct.	1976 July	1976 Oct.	1977 July	1977 Oct.
	Average number of borers per 100 stalks of corn[a]											
Northwest												
Bureau	5	85	0	86	8	20	4	177	1	15	0	142
Mercer*	10	57	..	179	3	46	0	132	2	134	6	234
Ogle*	2	46	0	173	7	9	0	218	5	59	1	106
Whiteside*	3	49	0	97	6	7	10	293	1	22	2	128
AVERAGE	5	59	0	134	6	21	3	205	2	41	2	153
Northeast												
DeKalb*	0	14	0	19	18	7	1	81	0	9	0	50
LaSalle	1	19	0	109	4	28	5	85	0	16	0	27
McHenry[b]*	0	16	8	140	..	5	1	95	4	9	0	32
AVERAGE	1	19	3	89	11	13	3	87	1	11	0	36
West												
Knox*	9	99	..	181	0	23	0	39	7	87	0	289
McDonough*	10	79	..	169	5	44	0	39	2	24	3	157
AVERAGE	10	89	..	175	3	34	0	39	5	56	2	223
Central												
Logal	2	11	0	15	1	28	0	7	0	5	1	39
McLean*	0	12	0	38	1	10	0	14	0	9	0	28
AVERAGE	1	12	0	27	1	19	0	10	0	7	1	34
East												
Champaign*	0	..	0	15	0	11	0	9	0	3	0	13
Iroquois*	0	22	0	126	0	15	1	30	0	26	2	23
Kankakee*	0	44	0	48	3	12	0	8	1	21	0	83
Livingston	0	25	0	107	4	11	1	30	0	3	0	32
AVERAGE	0	30	0	74	2	12	0	38	0	13	1	38
West-Southwest												
Christian	2	3	0	59	2	47	0	13	0	17	0	57
Greene	3	17	1	86	2	56	5	85	2	7	1	188
Madison[c]	0	6	0	236	5	40	0	42	3	57	10	227
Sangamon	0	6	3	38	0	26	0	8	0	11	2	26
AVERAGE	1	8	1	105	2	42	1	37	1	23	3	125
OVERALL AVERAGE	2	34	1	101	4	23	2	74	2	17	2	99

[a]Asterisks indicate an 11-county comparison (see Table 10).
[b]McHenry County replaces Boone County after July, 1976.
[c]Madison County replaces Macoupin County after July, 1976.

Table 8. Corn Borer Fall Population Surveys in 40 Illinois Counties, 1967-1977

District and county	Average number of borers per 100 stalks of corn										
	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977
Northwest											
Bureau	113	150	198	62	49	85	86	20	177	15	142
Jo Daviess	39	295	112	111	116	40	108	4	118	84	288
Mercer	76	217	331	42	164	57	179	46	132	134	234
Ogle	52	100	85	59	207	46	173	9	218	59	106
Whiteside	26	177	42	81	253	49	97	7	293	22	128
Winnebago	34	213	71	169	224	52	80	15	168	89	198
Average	57	192	139	87	169	55	121	17	184	67	183
Northeast											
McHenry	..	..	..	..	..	..	..	..	..	9	32
DeKalb	13	113	73	52	102	14	19	7	81	9	50
LaSalle	87	304	97	62	93	28	109	28	85	16	27
Average	32	148	75	62	89	14	85	12	73	11	36
West											
Adams	98	169	269	209	52	52	658	26	160	82	308
Brown-Cass	58	349	184	93	73	31	158	26	12	21	119
Henderson	115	287	367	50	193	149	162	9	100	100	363
Knox	136	300	183	85	63	99	181	23	39	87	289
McDonough	93	191	199	131	100	79	169	44	39	24	157
Average	102	233	235	130	108	84	246	28	64	67	247
Central											
Logan	30	41	13	3	60	11	15	28	7	5	39
Macon	23	52	28	11	68	14	6	29	7	7	58
McLean	82	267	46	24	65	12	38	10	14	9	28
Woodford	125	288	64	43	61	17	128	33	42	24	50
Average	90	187	84	27	67	17	71	25	26	11	44
East											
Champaign	7	80	12	9	34	..	15	11	9	3	13
Iroquois	21	321	69	17	123	22	126	15	30	26	23
Kankakee	41	94	66	53	204	44	48	12	8	21	83
Livingston	65	540	140	36	117	25	107	11	30	3	32
Vermilion	11	195	92	50	68	8	60	58	27	8	3
Average	29	246	76	33	109	25	71	21	21	12	31
West-Southwest											
Christian	74	158	44	30	64	3	59	47	13	17	57
Greene	..	..	..	..	..	..	..	..	..	7	188
Madison	107	425	447	270	233	19	268	152	214	57	227
Sangamon	16	84	7	16	57	6	38	62	8	11	26
Average	66	222	166	105	118	9	122	75	78	23	125
East-Southeast											
Clark	8	189	207	63	37	9	107	30	49	27	188
Effingham	..	..	..	..	..	..	..	..	..	38	217
Jasper	59	196	118	95	388	10	236	35	69	42	193
Marion	..	..	..	..	..	..	..	..	..	51	405
Moultrie	66	172	54	11	42	1	4	21	10	1	17
Average	37	189	138	56	130	8	100	28	36	32	204
Southwest											
Jackson	26	..	130	238	128	..	..	..	..	35	172
Pulaski-Alexander	13	163	189	70	13	1	8	24	26	14	250
St. Clair	110	357	444	58	365	46	259	97	155	44	448
Washington	..	..	..	..	..	..	..	..	..	51	283
Average	37	130	191	92	127	12	67	30	45	36	288
Southeast											
Franklin	2	236	..	..	238 1/	10 1/	..	..	..	42	207
Saline	33	382	406	30	179	7	..	..	..	52	222
Wayne	..	..	..	..	..	..	..	..	..	35	162
White	9	363	373	181	300	..	..	..	..	40	155
Average	11	245	195	53	179	4	..	..	..	42	187
STATE AVERAGE	55	226	156	76	133	34	123	31	78	36	155

1/ Franklin and Jefferson counties sampled as one.

Table 9. Average First- and Second-Generation Corn Borer Populations, 1967-1977 (11-County Comparison)[a]

Year	Number of borers per 100 stalks of corn: First generation	Second generation
1967	9	51
1968	3	183
1969	5	105
1970	1	57
1971	5	126
1972	3	40
1973	1	108
1974	4	17
1975	1	87
1976	2	37
1977	1	104

[a]Starred counties, Table 7.

Table 10. Hessian Fly Populations, by Sections, July 1967-1977

Section	Flaxseeds per 100 tillers: 1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977
West	2.5	1.0	1.0	.4	0	0	0	1	0	0	0
Central	1.0	0	1.0	.8	0	6.0	0	1	0	0.8	3.2
East	.5	0	0	0	..	..	..	..	..	..	.8
West-southwest	3.7	.18	1.0	3.1	2.3	1.0	0	5	1.2	3.0	1.0
East-southeast	4.2	4.3	3.0	1.2	5.5	4.0	1.3	1	2.1	1.6	0.8
Southwest	2.8	4.2	3.0	6.2	1.2	3.0	5.6	0	7.2	1.3	9.4
Southeast	13.0	2.0	2.0	4.4	1.2	14.0	6.0	2	.4	0.8	.8
STATE AVERAGE	5.3	1.9	2.0	3.3	2.0	4.4	2.2	2	1.7	1.3	3.1

THE PESTICIDE DILEMMA

Steve Moore III

Use and Benefits of Pesticides

The use of pesticides in agriculture has increased dramatically during the past 30 years (Tables 1, 2, 3, 4). Farmers are continuing to rely heavily on pesticides to manage their pest problems. Cultural practices such as crop rotation, rotary hoeing, and cultivation for weed management and the use of resistant or tolerant varieties as insect and disease deterrents are also widely utilized by farmers as pest management tools.

Efficiency in agriculture is the key to an adequate supply of wholesome and appetizing foods at a resonable cost to the consumer. Pesticides have played an important role in improving agricultural efficiency and have also helped greatly to reduce human, animal, and plant diseases as well as to provide us with more comfortable living (Tables 5, 6).

What the future would be like without pesticides has been described by Dr. William Hollis of the National Agricultural Chemicals Association:

"Total output of crops and livestock combined would be reduced immediately by at least 30 percent.

"The price of farm products could be expected to increase by 50 to 57 percent.

"Farm exports would be eliminated.

"The number of agricultural workers currently on farms would be doubled.

"Instead of spending 17 percent of family income for food we would be forced to devote 30 to 40 percent of our income and perhaps even more to provide for current food needs.

"Without increasing the amount of land in farm crops, we could not provide food for more than 40 percent of our current population."

Risks

Certain pesticides, mainly insecticides like DDT, aldrin, dieldrin, heptachlor, and chlordane, have been found to persist in cropland soil (Table 7). They also are absorbed from the soil by certain crops, especially those with a high oil content like soybeans, and are translocated to the seed (Tables 8 and 9).

Residues of many of these same insecticides are found in cow's milk and the fat of beef cattle (Tables 10 and 11). A noticeable decline in existing residue levels for certain of these insecticides in cow's milk has already occurred, and a similar lessening of residue levels is expected in soybeans and beef cattle fat in the future.

There is little use of these insecticides currently by Illinois farmers. None of the newer alternative insecticides being used by farmers are leaving illegal residues in these commodities.

The amount of major pesticides, mainly insecticides, present in our food supply as determined by the market-basket survey (1965-1974) is compared to these acceptable daily intake levels established by FAO and WHO (Table 12). The dietary intake levels for all pesticides were well below the Acceptable Daily Intake (ADI) except for dieldrin, which equaled the ADI in the 1966 survey (Table 12). In recent years there has been a general decline in the residue levels of pesticides in our food supply. The residues in human fat for the major insecticides having persistent and bioaccumulative properties leveled off or declined between 1970 and 1974 (Table 13).

Pesticide levels in Illinois drinking water were found to be considerably below the allowable limits (Table 14). Measurements of atmospheric levels of pesticides by Charles Stanley and others published in *Environmental Science and Technology*, Volume 5, No. 5, in 1971 showed the levels of pesticides in the ambient air to be almost entirely below levels that might add to the total human intake of pesticides.

The number of persons accidentally exposed to pesticides as reported by poison control centers in Illinois has shown a gradual decline in the last 15 years (Table 15) An average of 2.2 persons have died each year from pesticides since 1960 (Table 16). Only one of the 35 deaths was due to an agricultural use of pesticide, in spite of the fact that approximately 60 percent of all pesticides is used in commercial agriculture.

Any pesticide that causes tumor formation at any dosage is considered by the U.S. EPA to have an unreasonable adverse environmental effect since benign tumors can become malignant. Aldrin and dieldrin labels for use on food and feed crops and most other uses were cancelled by the U.S. EPA administrator because of this effect. Many other pesticides may not be registered because of their tumor-producing (oncogenic) risk.

The death rate in humans from cancer has leveled off in recent years (Table 17). This decrease in cancer deaths parallels the advent and widespread usage of synthetic organic pesticides in agriculture.

The primary documented black marks against pesticides are the adverse effects of certain chlorinated hydrocarbon insecticides like DDT and dieldrin on certain fish and birds as a result of normal use. There have been some fish kills from improperly handled wastes from pesticide manufacturing plants and human illness involving workers in pesticide manufacturing and formulating plants.

Future of Pesticides

Currently the U.S. EPA has tentatively listed 64 pesticides it feels should not be registered (Tables 18, 19, 20). This is called the Rebuttable Presumption Against Registration list (RPAR). A total of 26 pesticides have already had some or all of their registered uses cancelled or suspended (Table 21).

Tightening of regulations and more stringent requirements have already had an impact on the development of new pesticides (Tables 22, 23). The number of major pesticides now reaching the market each year has declined dramatically in the last five years (Table 24).

In summary it can be stated that pesticides have brought great benefits to society and like other new advancements, there are some risks. Agriculturists have shown that they can and do use pesticides safely and judiciously. Farmers and commercial pesticide applicators are better trained than ever before and now must prove their competency (by being licensed) to apply many pesticides. Their record is good and it can be kept that way.

Good judgment and a rule of reason on pesticide risks by legislators and regulatory agencies are needed for the pesticide industry to survive. Regulations need to be reasonable and practical. We cannot protect every person from every hazard by laws and regulations. Education and understanding are usually the better way, if we are to continue to progress.

Pesticides are still our most efficient means of managing pest problems, and they should remain so for many years to come. I am optimistic that this is the wish of society.

Table 1. Insecticide Use In Illinois On Field Crops 1953-1976[a]

Year	Acres treated	Profit
1953	770,625	$ 8,596,995
1954	1,095,165	7,130,258
1955	1,532,859	13,983,855
1956	1,405,624	7,097,630
1957	934,224	2,696,960
1958	1,085,660	3,023,223
1959	1,730,418	5,444,334
1960	2,182,114	6,903,016
1961	3,414,582	10,828,806
1962	5,398,151	22,789,035
1963	5,815,197	23,197,432
1964	5,202,480	18,775,550
1965	5,589,583	27,659,463
1966	6,011,083	29,593,337
1967	6,730,845	33,026,152
1968	7,115,207	34,434,233
1969	7,876,823	36,413,387
1970	7,368,101	27,501,930
1971	6,809,905	23,092,825
1972	6,768,851	23,765,461
1973	7,194,618	24,018,473
1974	6,991,713	39,801,603
1975	7,268,590	46,823,220
1976	8,186,370	52,350,230

[a]Based on data provided by county extension advisers.
[b]Profit realized by farmers over and above treatment costs.

Table 2. Illinois Pesticide Usage 1972-1976[a]

	Corn	Soybeans	Small grain	Hay
		Acres treated		
1972				
Herbicides	8,165,000	6,241,600	23,500	16,100
Insecticides	5,507,100	443,700	30,200	119,600
1976				
Herbicides	11,438,600	7,219,800	114,000	22,800
Insecticides	6,738,400	294,800	45,800	152,400
		Percent of acres treated		
1972				
Herbicides	86.0	83.0	1.4	1.4
Insecticides	58.0	5.9	1.8	10.4
1976				
Herbicides	95.4	95.5	5.0	1.9
Insecticides	56.2	3.9	2.0	12.7

[a]From "Pesticide Use by Illinois Farmers, 1976." Issued by Illinois Department of Agriculture and Compiled by Illinois Crop Reporting Service.

Table 3. Quantities of Pesticides Used on Farm Crops in the Corn Belt[a] *in 1964, 1966, and 1977 (in thousands of pounds of active ingredient)*

Pesticide/Crop	1964	1966	1971
Herbicides on			
Corn	12,590	27,473	54,069
Soybeans	3,024	6,567	18,875
All other crops	1,381	1,440	3,407
All crops	16,995	35,480	76,351
Insecticides on			
Corn	10,812	17,525	15,314
Soybeans	516	244	117
All other crops[b]	3,030	3,688	2,993
All crops	14,358	21,457	18,424
Fungicides on			
Corn	.1	negl.	negl.
Soybeans	.2	negl.	negl.
All other crops[2]	7.9	5.4	5.3
All crops	8.2	5.4	5.3

[a]Corn Belt = Illinois, Indiana, Iowa, Missouri, and Ohio.
[b]Apples, vegetables, other field crops (mainly outside of Illinois and Iowa).
Sources: U.S. Department of Agriculture, 1968b, 1970b, 1974.

Table 4. Pesticide Use in United States, 1966 and 1971[a]

Pesticide	Total U.S. use (1,000,000 lb. a.i.) 1966	1971	Increase	Farm use (1,000,000 lb. a.i.) 1966	1971	Increase	Farmer's share of total use 1966	1971
Herbicides	227	359	58%	125	251	101%	55%	70%
Insecticides	329	319	-3%	195	201	3%	59%	63%
Fungicides	125	155	24%	33	42	27%	26%	27%
Total	681	833	22%	353	494	40%	52%	59%

[a]From "Production, Distribution, Use and Environmental Impact Potential of Selected Pesticides, 1975" by Rosemarie Von Rumker, *et al.* for Office of Pesticide Programs, U.S. EPA., p. 23

Table 5. Food Expenditures and Income Trends 1960-1973[a]

Year	Food expenditures as percentage of income (excluding alcoholic beverages)
1960	20.0
1961	19.8
1962	19.3
1963	18.9
1964	18.4
1965	18.1
1966	18.0
1967	17.2
1968	16.9
1969	16.4
1970	16.2
1971	15.7
1972	15.7
1973 (est.)	16.4

[a]Handbook of Agricultural Charts, Based on data of Department of Commerce.

Table 6. Years of Life Expectancy at Birth 1910-1974[a]

Year	Years of life expected from birth: Male	Female	Both
1910	45	48	47
1920	52	55	53
1930	58	62	60
1940	62	65	64
1950	67	71	69
1960	68	74	70
1970	67	75	71
1974	68	77	73

[a]Division of Vital Statistics, National Center for Health Statistics, 1974.

Table 7. Pesticide Residues in Cropland Soil, 1969-1970[a]

Insecticide	Concentration in ppm 1969 U.S.	1969 Ill.	1970 U.S.	1970 Ill.
Atrazine	0.01	<0.01	...	...
chlordane	0.04	0.23	0.08	0.25
DDT	0.26	<0.01	0.28	0.02
dieldrin	0.05	0.24	0.06	0.23
endrin	<0.01	...	<0.01	...
Furadan	<0.01	...	...	...
heptachlor	<0.01	0.05	0.02	0.05
lindane	<0.01	...	<0.01	<0.01
malathion	0.01	...	...	...
parathion	0.06	...	...	...
Ramrod	...	...	<0.01	...
Thiodan	<0.01	...	<0.01	...
toxaphene	0.07	...	0.06	...
trifluralin	<0.01	<0.01	<0.01	<0.01

[a]From "National Soils Monitoring Program for Pesticides Residues-FY 1969-1970," U.S. EPA.

Table 8. Dieldrin Residues in Soybeans in Illinois, 1965-1974

Year	Residue in soybeans in ppm[a] All fields	Treated fields[b]	Untreated fields[c]
1965	.0089	.0101	.0068
1966	.0077	.0119	.0043
1967	.0102	.0187	.0061
1971	.0101	.0165	.0058
1974	.0136	.0190	.0110

[a]Residues in parts per million (ppm) based on the weight of the whole bean.
[b]Fields having a history of aldrin treatment when in corn.
[c]Fields in which no aldrin had been applied.

Table 9. Insecticide Residues in Soybeans in Illinois in 1974

Insecticide	Residues in soybeans in ppm[a] All fields	Treated fields[b]	Untreated fields[c]
dieldrin	.0136	.0190	.0110
heptachlor	.0054	.0093	.0052
chlordane	.0018	.0352	.0013
Total	.0208	.0635	.0175

[a]Residues in parts per million (ppm) based on the weight of the whole bean.
[b]Fields having a history of aldrin treatment when in corn.
[c]Fields in which no aldrin has been applied.

Table 10. Occurrence and Amount of Insecticide Residues in Bovine Fat in Illinois, 1971-1973

Insecticide	Average ppm[a] 1971	1972	1973	All years
BHC[b]	..	trace	trace	trace
Chlordane[b]	..	..	trace	trace
DDT[c]	.04	.06	.16	.14
dieldrin[b]	.04	.04	.05	.04
endrin[b]	trace	trace	trace	trace
heptachlor[b]	.03	.04	.03	.03
lindane[c]	trace	trace	trace	trace
methoxychlor[d]	..	trace	trace	trace

[a]Residue expressed in part per million (ppm).
[b]No tolerance for residues in meat fat.
[c]Official tolerance is 7 ppm in meat fat.
[d]Official tolerance is 3 ppm in meat fat.

Table 11. Occurrence of Insecticide Residues in Cow's Milk and Manufactured Milk Products in Illinois, 1971-1976 (Total Samples 1,169)

Insecticides	1971 % pos.[a]	1971 Avg. ppm[b]	1972 % pos.	1972 Avg. ppm.	1973 % pos.	1973 Avg. ppm	1974 % pos.	1974 Avg. ppm.	1975 % pos.	1975 Avg. ppm.	1976 % pos.	1976 Avg. ppm.	All years % pos.	All years Avg. ppm.
chlordane	39	.02	100	.04	88	.06	76	.05	24	.01	84	.03	69	.03
DDT[c]	92	.05	91	.02	92	.03	64	.01	17	.01	43	.01	48	.01
dieldrin	100	.08	100	.04	92	.08	92	.08	96	.09	99	.09	96	.09
heptachlor	100	.03	88	.03	93	.05	86	.03	94	.04	96	.05	93	.04
lindane	8	tr.	88	.02	85	.03	83	.02	92	.01	56	.01	73	.01
Total	100	.18	100	.15	100	.25	98	.19	100	.17	100	.19	100	.18

[a]% pos. = Percent positive samples.
[b]Avg. ppm = Average part per million of residue present on a fat basis.
[c]Official tolerance is 1.25 ppm in milk fat.

Table 12. Dietary Intake of Some Insecticides in United States, 1964[1]

Pesticide	FAO-WHO acceptable daily intake level (mg/kg)	Daily intake of insecticides (mg/kg) 1965	1966	1967	1968	1969	1970	1973	1974
BHC	...	.00003	.00004	.00003	.00004	.00002	.00002	.000009	.00002
carbaryl (Sevin)	.02	.002	.0005	.0001	...	.00004	...	.00001	.00005
DDT	.005	.0009	.001	.0008	.0007	.0005	.0004	.0001	.00008
diazinon	.002	...	.00002	.000001	.000001	.000004	.00001	.00002	.00002
dicofol (Kelthane)	...	.00004	.0001	.0002	.0001	.0001	.00005	.000007	.0000008
dieldrin	.0001	.00009	.0001	.00006	.00006	.00007	.00007	.00004	.00004
endrin	...	.000009	.000004	.000004	.00001	.000004	.0000005	.0000005	.00000
heptachlor	.0005	.00003	.00005	.00002	.00003	.00003	.00002	.000006	.00001
lindane	.0125	.00007	.00006	.00007	.00004	.00002	.00002	.000003	.000008
malathion	.02	...	.0001	.0002	.00004	.0002	.0002	.0002	.0001
parathion	.005	.000001	.000005	.00001	...	.00001	.000003	.000003	.000002
Total chl. hydro.	...	.0012	.0016	.0012	.0010	.0008	.0006	...	...
Total organophasphate	...	...	.00014	.00025	.00007	.00023	.00023	...	...
Total herbicides	...	.00012	.00022	.00005	.00006	.00005	.000008	...	...

[1]*Pesticide Monitoring Journal*, September, 1971, and *FY74 Total Diet Studies* (7320.08).

Table 13. Insecticide Residues in Human Fat[a]

Insecticide	Concentration in ppm, lipid basis 1970	1971	1972	1973	1974
DDT	7.88	7.95	6.88	5.88	4.99
BHC	.37	.34	.23	.26	.21
heptachlor	.09	.09	.08	.09	.08
dieldrin	.18	.22	.18	.18	.15
chlordane	...	.11	.11	.12	.12
lindane	...	...	...	.10	.10

[a]From "Survey of Pesticide Residues and Their Metabolites in the General Population of the United States." F.W. Kutz, *et al.* Ecological Monitoring Branch, U.S. EPA.

Table 14. Illinois Quality Standards for Pesticides and Residue Levels in Drinking Water[a]

Pesticide	Maximum allowable concentration, ppm[b]	Screening levels, ppm[c]
aldrin	.001	.00005
chlordane	.003	.00005
DDT	.05	.0001
dieldrin	.001	.0001
endrin	.0005	.0001
heptachlor	.0001	.00005
heptachlor epoxide	.0001	.00005
lindane	.005	.00005
methoxychlor	.1	.0005
toxaphene	.005	.005
parathion and other organophosphate	.1	...
2,4-D	.02	...
2,4,5-T	.01	...

[a]From *"208" Update for Agriculture* Vol. 1 (4) Jan. 1977. Cooperative Extension, University of Illinois. A total of 139 water supplies were each sampled every 5 months from 1974 to 1976. Pesticide levels were found to be considerably below the allowable limits (see table). Dieldrin was the most frequently detected pesticide.
[b]ppm = parts per million
[c]When a pesticide exceeds the screening level, the sample is retested to determine the exact amount of pesticide present.

Table 15. Number of Persons Treated for Pesticide Exposure at Poison Control Centers in Illinois, 1961-1976

Year	Number treated
1961	567
1963	819
1965	872
1967	801
1969	678
1971	469
1973	487
1975	407
15-year average	647

Table 16. Accidental Pesticide Deaths in Illinois 1960-1975 (16-Year Period)

Year	Deaths[a]
1960-62	10
1963	1
1964	1
1965	4
1966	7
1967	0
1968	1
1969	4
1970	2
1971	2
1972	2
1973	1
1974	0
1975	0
Total	35
Average per year	2.2

[a]Thirty-four of the 35 deaths resulted from pesticides used or stored in and around the home. One death occurred with a pesticide used for agricultural purposes.

Table 17. Death Rate From Cancer in United States[a]

Year	All cases, number per 100,000 population	Lung cancer, number per 100,000 population	Cancer cases excluding lung cancer, number per 100,000 population[b]
1930	112	..	...
1940	120	..	...
1950	125	11	114
1960	125	18	107
1970	130	26	104
1971	131	27	104
1972	131	29	102
1973	131	29	102
1974	132	..	...
1975	131	31	100

[a]"1977 Cancer Facts and Figures," American Cancer Society.
[b]Except for lung cancer, age-adjusted cancer death rates are leveling off and in some cases have declined. Most lung cancers are caused by cigarette smoking.

Table 18. Number of Pesticides on U.S. EPA Proposed Rebuttable Presumption Against Registration (RPAR), April, 1977

Type of pesticide	Number
Insecticides	23
Herbicides	17
Wood preservatives	8
Fungicides	7
Rodenticides	3
Disinfectants, deodorants	3
Miscellaneous	3
Total	64

[a]Forty-nine of the 64 pesticides are candidates for RPAR because of oncogenic (causing tumors) or carcinogenic (causing cancer) risk. It is estimated that these pesticides represent 14,000 to 20,000 registered products.

Table 19. Some Commonly Used Pesticides on Proposed RPAR List[a]

Pesticide	Use category	Reason for RPAR
benomyl (Benlate)	fungicide	bioaccumulative
carbaryl (Sevin)	insecticide	tumorgenic
carbon tetrachloride	insecticide	tumorgenic
creosote	wood preservative	carcinogenic
dichlorvos (DDVP, Vapona)	insecticide	mutagenic
dimethoate (Cygon-Defend)	insecticide	tumorgenic
EPN	insecticide	neurotoxic
ethylene dibromide	insecticide	tumorgenic
kepone	insecticide	tumorgenic
paraquat	herbicide	carcinogenic
perthane	insecticide	tumorgenic
piperonyl butoxide	insecticide	tumorgenic
rotenone	insecticide	tumorgenic
2,4,5-T	herbicide	teratogenic
trichlorfon (Dylox)	insecticide	tumorgenic

[a]Rebuttable Presumption Against Registration (RPAR) list prepared by the U.S. EPA in April, 1977.

Table 20. Current Pesticides on U.S. EPA Rebuttable Presumption Against Registration (RPAR) List

1. BAAM	6. EBDC (Maneb, Zineb)	11. strychnine sulfate
2. BHC	7. endrin	12. 1080
3. chlorobenzilate	8. lindane	13. 1081
4. chloroform	9. pronamide	14. toxaphene
5. diallate	10. strychnine	

Table 21. Cancelled or Suspended Pesticides (Some or All Uses)

aldrin	lindane
alkyl mercury	mercury comp.
arsenic trioxide	OMPA
BHC (Tech. grade)	safrole
basic copper arsenate	sodium cyanide
chloranil	sodium fluoride
chlordane	1080
DBCP	strobane
DDT	strychnine
dieldrin	TDE*
endrin	2,4,5-T
heptachlor	thallium sulfate*
kepone	vinyl chloride*

*All uses cancelled.

Table 22. Chance for a New Pesticide To Become a Product[a]

Year	Odds
1956	1 in 3,000
1964	1 in 4,000
1969	1 in 6,000
1971	1 in 7,000
1975	1 in 15,000

[a]Dr. Wendell Mullison, Proceedings, 30th North Central Weed Control Conference, Milwaukee, Wisconsin, December, 1975.

Table 23. Cost of Developing a Pesticide[a]

Year	Millions of dollars
1956	1.2
1964	2.5
1969	4.1
1971	9.8
1975	13.2

[a]Dr. Wendell Mullison, Proceedings 30th North Central Weed Control Conference, Milwaukee, Wisconsin, December, 1975.

Table 24. Number of Major Pesticides Introduced in the United States, 1931-1975[a]

Years	Number of new major pesticides
1931-1940	2
1941-1950	9
1951-1960	17
1961-1970	19
1971-1975	3

[a]Dr. Wendell Mullison, Proceedings, 30th North Central Weed Control Conference, Milwaukee, Wisconsin, December, 1975.

SPRAYING SOYBEANS FOR DISEASE CONTROL

B.J. Jacobsen, T.M. Sjulin

1977 was an excellent year to test foliar fungicides for soybean disease control since weather conditions were favorable for disease development. The warm, wet weather in August and September and the above-normal rainfall in October favored the development of the leaf disease Septoria brown spot *(Septoria glycines)*, and the stem diseases pod and stem blight *(Diaporthe phaseolorum* var. *sojae*, *Phomopsis* spp.) and anthracnose *(Colletotrichum dematicum* var. *truncata)*.

Both small-plot trials and large-scale aerial trials were conducted in Champaign County near Tolono, in cooperation with Illinois Foundation Seeds, Inc. A large field of Amsoy 71 was chosen for use in both trials. Twenty-five different treatments were used in small-plot studies and nine different treatments in the aerial trial. Small plots (4 rows, 25 feet long) were treated using a Solo backpack mistblower at 38 gallons per acre. Aerial plots were 50 x 200 feet with 50-foot borders. Fungicides were applied at 5 gallons per acre by a Bell D-1 helicopter (boom 5 to 7 feet over crop). Five replications were used in the small-plot trial, and three replications were used in the aerial application trial.

Initial applications were made to the small plots when pods in the upper one-half of the plant were just beginning to form (1/4 inch or less in length). A second application was made 21 days later. Aerial applications were made 7 days after the applications to small plots, when pods in the upper one-half of the plant averaged 1/2 to 1 inch in length. The second application was made 21 days after the first.

Results of the 1977 fungicide trials are given in Tables 1 and 2; data include percent defoliation by *Septoria glycines* and physiological maturity on September 9, percent stem discoloration by pod and stem blight and anthracnose, and yield. Seed weight and seed quality data were not available at the time of this writing.

Other trials in commercial fields conducted in several locations throughout Illinois using Benlate according to label instructions showed yield increases of 1.5 to 6 bushels per acre. In most cases growers used the checklist developed by the DuPont Company and researchers here at the University of Illinois and elsewhere. This checklist, described in Table 3, proved to be a reliable indicator of the need for fungicide application to soybeans. While this checklist was made to predict the need for Benlate application, it seems logical that it would apply to other fungicides. The presence of pycnidia on fallen petioles at the decision time for the first spray is of particular value since this presence indicates that the pod and stem blight fungus is present and active.

Conclusions

Septoria brown spot control. Fungicide treatments including Duter, Benlate, Difolatan (two applications, 2 or 4 pints), Bravo, Captan, Benlate-Du-Ter, and Benlate-Captan gave good control both in the 1977 trial and in trials conducted in 1976 (see 1977 manual). In addition, Benlate-Difolatan, Mertect-Du-Ter, and Mertect-Difolatan gave good control in the 1977 trial. Since *Septoria* is active before the initial spray application is applied, it is unlikely that excellent control will be achieved with any fungicide. Control of this disease is a primary factor in delayed maturity. Maturity was delayed in the 1977 trials from 4 to 7 days by fungicide treatments. Yield is most likely to be increased by this delay in maturity.

Stem diseases. Most fungicides tested gave good to fair control of the pod and stem blight and anthracnose diseases in 1976 and 1977 trials. Exceptions to this were Bayleton, BASF 352, BTS 40-542, Mertect 340 F (6 and 8 fluid ounces per acre), and Captan, all of which did not differ from the untreated in 1977.

Control of the pod and stem blight and anthracnose diseases is important if increases in seed quality due to reduced fungal infections are to be found. Control of these stem diseases is also important if premature plant kill due to disease is to be avoided.

Yield. Overall, those treatments that gave the best control of Septoria brown spot and the stem diseases provided the best yields. The Benlate-Du-Ter combination provided high yields in both 1976 and 1977 trials while Benlate-Difolatan, Du-Ter (1.0 pound per acre) and Difolatan (4 pints, two applications applied at 30-day interval) also gave statistically significant yield increases in 1977 trials. Benlate-Captan and Benlate gave large but nonsignificant yield increases in 1977.

While there were no statistically significant increases in yield in the aerially applied trials, it is of interest that the Benlate and Difolatan treatments that gave the best Septoria and stem disease control had the highest yields. Differences in yield in the aerial and small-plot trials may reflect difference in application efficiency, timing, or both, since the aerial applications were applied 7 days later than applications on the small plots. The difference in defoliation data most likely reflects the differences in date of data collection. Defoliation data were taken in the aerial plot 5 days before those taken in the small plot.

Table 1. Illinois Soybean Fungicide Trial, Champaign County, 1977

Material	Rate of product per acre[a]	Yield (bu./A.)	Percent defoliation on September 7	Percent stem discoloration at maturity
Untreated	...	51.3	96.8	57.3
Benlate 50W	.5 lb.	56.8	82.0*	40.9*
Captan 50W	4.8 lb.	54.4	90.0*	52.2
Benlate + Captan	.33 lb. + 3.2 lb.	57.0	86.0*	45.1*
Difolatan 4F	2.0 pt.	53.4	84.0*	40.7*
Difolatan 4F	4.0 pt.	56.3	82.0*	39.8*
Difolatan 4F	4.0 pt.[b]	56.5	92.0	49.7*
Difolatan 4F	4.0 pt.[c]	57.7*	81.6*	35.0*
Benlate + Difolatan	.25 lb. + 2.0 pt.	53.9	74.0*	38.6*
DPX-140 67W	1.5 lb.	58.4*	78.0*	37.3*
Du-Ter 47.5W	.5 lb.	52.7	88.6*	45.7*
Du-Ter 47.5W	1.0 lb.	59.4*	84.0*	39.3*
Benlate + Du-Ter	.25 lb. + .25 lb.	62.0*	81.0*	42.3*
DPX-10 50W + Du-Ter	.13 lb. + .25 lb.	54.1	86.0*	44.4*
Mertect 340F	6 fl. oz.	53.2	95.6	52.2
Mertect 340F	8 fl. oz.	52.2	91.0*	52.0
Mertect 340F	10 fl. oz.	52.0	92.0	49.5*
Mertect + Difolatan	6 fl. oz. + 1.5 pt.	54.1	86.0*	49.0*
Mertect + Du-Ter	6 fl. oz. + .25 lb.	54.6	88.0*	45.3*
Bravo 6F	2.0 pt.	53.2	85.0*	45.7*
Bayleton 50W	.5 lb.	53.2	96.2	53.1
Bayleton 50W	1.0 lb.	49.4	96.8	54.6
BASF 352 50W	1.0 lb.	52.0	96.4	56.0
BASF 352 50W	2.0 lb.	48.9	96.8	55.8
BTS 40-542 25EC	1.3 fl. oz.	49.4	95.6	57.8
Flsd(0.05)		5.8	5.1	6.6

[a]Fungicides were applied in 38 gallons of water per acre with a backpack mistblower on July 14 and August 4; the soybean variety was Amsoy 71.
[b]One application only, July 14.
[c]Two applications, July 14 and August 11.
*Significantly different from untreated at $P = 0.05$.

Table 2. Aerial Application of Soybean Fungicides, Champaign County, 1977

Material	Rate of product per acre[a]	Yield (bu./A.)	Percent defoliation on September 2	Percent stem discoloration at maturity
Untreated	...	47.2	98.0	55.8
Mertect 340F	6 fl. oz.	48.7	86.0	55.5
Mertect 340F	8 fl. oz.	47.8	85.2	59.3
Mertect 340F	10 fl. oz.	47.9	83.2	55.0
Bravo 6F	2.0 pt.	48.1	80.5	59.0
Captan 80W	3.0 lb.	48.8	80.0	56.5
Benlate 50W	.5 lb.	49.8	78.3	46.7*
Captan + Benlate	2.0 lb. + 0.33 lb.	50.6	76.0	58.8
Difolatan 4F	2.0 pt.	51.2	76.7	48.0*
Flsd(0.05)		n.s.	n.s.	4.3

[a]Fungicides were applied in 5 gallons of water per acre with a Bell D-1 helicopter on July 21 and August 11 and 12; the soybean variety was Amsoy 71.
*Significantly different from untreated at $P = 0.05$.

Table 3. Check List To Determine if Fungicide Application Should Be Made to Soybeans

Risk factors	Point value if the answer is yes
1. Rainfall, dew, and humidity up to early bloom and pod set:	
Below normal.	0
Normal.	2
Above normal.	4
2. Soybeans in the field last year	4
3. Chisel-plow, disk, or no-till	1
4. Pycnidia (small dark spots) visible on fallen petioles and Septoria blotch obvious on lower leaves	2
5. Early-maturing variety (not full-season).	1 to 2
6. Beans to be used or sold for seed	3
7. Yield potential better than 35 bushels per acre	2
8. Seed quality at planting less than 85% germination.	1
9. Field relatively free of a weed canopy.	2
10. Other conditions that favor disease development (weather forecast with 30-day period of greater-than-normal rainfall and disease history).	1 to 3

NOTE: If the total is 10 points or higher, benefits in terms of total increased yields and higher seed quality will likely occur.

BIRD CONTROL IN AND AROUND FARM BUILDINGS

R.D. Ogden

Problems Associated With Birds

The control of birds is one of the most difficult operations a pest control specialist can perform because many birds are protected by law or ordinance. Although many birds are well known residents of cities, towns, and rural areas, few people realize that birds are associated with several diseases of humans, that a number of parasites of birds may irritate or bite humans, or that birds may play a very important role in food contamination. In addition, some bird populations destroy crops and build nests that attract and support insect pests.

Certain birds that live near humans present a potentially serious epidemiological problem because these birds may harbor diseases. One of the most publicized diseases, pigeon ornithosis (psittacosis in parrot-like birds), is similar to viral pneumonia and can be transmitted to man through infected droppings or respiratory droplets. Surveys have shown that as much as 30 to 75 percent of a pigeon flock may be visibly infected. Because diagnosis of the disease in humans is rather difficult, it is often called flu or atypical pneumonia. This disease is undoubtedly more important than is commonly realized.

Many species of birds, including pigeons, house sparrows, and starlings, have been implicated as reservoirs of organisms causing encephalitis. These diseases of the central nervous system are transmitted from birds to humans by mosquitoes, but the exact role of birds in the epidemiology of encephalitis is as yet unknown.

Several outbreaks of systemic fungal diseases in humans, principally histoplasmosis, caused by *Histoplasma capsulatum*, and cryptococcus, caused by *Cryptococcus neoformans*, have been traced to pigeon, starling, and bat manure. *Salmonella typhimurium*, which causes food poisoning, has been found in substantial portions of pigeon flocks. Toxoplasmosis, a disease caused by the protozoan *Toxoplasma gondii*, is frequently found in pigeons, and has been known to be transmitted from pigeons to humans.

Bird ectoparasites, which frequently invade buildings where birds are nesting, may bite humans. Most bird pests are infested with lice and mites, and these frequently migrate from birds or their nests into buildings. Other ectoparasites associated with birds include bedbugs, bat bugs, louse flies, fleas, and ticks. Food must be protected in transportation, storage, processing, or food service establishments. Control personnel should be alert to protecting food from all sources of bird contamination, including feathers, fecal matter, nesting materials, and ectoparasites.

Another problem occurs in airport areas, where birds can seriously damage aircrafts if they collide with them. A number of jet aircrafts and human lives have been lost as a result of such collisions. Birds that suddenly rise from runways or surrounding areas and collide with planes during takeoff or landing are especially hazardous during these critical phases of flight. Bird control and management must therefore be practiced in these areas.

Birds Needing Control

The principal birds to be controlled in urban and rural situations are the common pigeon, *Columba livia* (Gmelin); the European starling, *Sturnus vulgaris* (Linnaeus); the English sparrow, *Passer domesticus* (Linnaeus); and the red-winged blackbird, *Agelaius phoeniceus*. Species such as brownheaded lovebirds, common grackles, robins, and woodpeckers may at times require control.

Pigeon (Rock Dove)

Pigeons are pests in towns and cities. Only rarely do they appear in any great number in rural areas, except around feed mills and cattle or hog feeding farms. In cities these birds tend to move about and roost in flocks of several hundred. Occasionally a smaller group will select a house or a few houses on which to roost, but usually pigeons prefer large buildings. They build their nests of small twigs on roofs, ledges, and even in drain spouts, which can get stopped up with debris and dead birds.

Pigeons feed mainly on grains and other seeds, but will occasionally eat fruits or vegetables. They feed near grain elevators, parks and zoos, or any other place where food is available to them. An adult pigeon consumes about one pound of food per week. Pigeons also need water and grit, such as gravel or sand, which is used to grind food in the gizzard. Pigeons are creatures of habit and tend to feed, nest, and roost in the same places, usually in protected areas up high. An understanding of pigeon behavior is important if extensive and involved control measures are necessary.

European Starling

Starlings, which are pests in both cities and rural areas, travel in flocks, as do pigeons. In rural areas starlings nest in tree cavities and on ledges about farm buildings. Starlings are not usually bothersome except around grain elevators, corn fields, and fruit trees, and in cattle and hog feeding lots, where they can easily devour enough food to cause serious economic loss. Starlings are dark, short-tailed birds between sparrows and pigeons in size. From a distance starlings look entirely black, but they are actually flecked with light colors, many of their feathers showing irridescent purples and greens. Some people confuse starlings with blackbirds, but a blackbird does not have the short tail or yellow bill of a starling. The silhouette of a starling in flight can help to identify this bird.

Starlings normally spend warm weather in rural areas. When it gets cold in the fall, however, they will move in large flocks into towns and cities at night to seek the warmth and shelter of big buildings or to roost in large numbers in trees in residential areas and city parks. During daylight hours they will fly many miles in search of food, only to return to the roosting site again at night. Starlings take off from their roosts when anything unusual, such as a sudden noise or flashing lights, occurs. They become accustomed quickly to regular noise, however, and are not disturbed by heavy traffic and flashing neon lights. Although only three to six eggs are laid, usually twice a year, starlings are quite hardy and are able to survive under difficult conditions, with the result that great flocks are formed.

Starlings are objectionable because of roosting in large numbers on or near buildings. These roosts are the source of much dirt and noise. Since control primarily involves preventing the birds from using certain trees and buildings as roosts, it is necessary to understand starling roosting behavior. During the mating season mated birds disperse to care for their young, while a few unmated birds still travel together between roosts and feeding grounds. "Two broods of young and the parent birds later" join the roosting flocks, thus greatly increasing the flock size about mid-summer. From then until late fall the birds continue to use the summer roosts, which are often in trees. Migration may occur when the birds leave their summer roosts. The remaining birds usually shift their roosts to city buildings, where they stay throughout the winter.

English Sparrow

The United States has many species of sparrows, none of which is a serious pest. The most common pest species is the English sparrow, a name so deeply ingrained in everyday vocabulary that it will probably never by abandoned. This bird, however, is not a true sparrow, but belongs to a family whose members are properly called weaver finches. Because it is very active and argumentative, this small bird, which moves in flocks, can be a nuisance out of all proportion to its size. It is a pest in gardens and orchards and around buildings, where it builds its nest. Sparrows in any numbers will frequently drive small songbirds out of an area.

Sparrows almost invariably build their nests in or near buildings. These nests of twigs, grass, and paper, or almost anything else the bird can carry, are built in gutters or on roofs and ledges of buildings, or inside buildings on roof supports. Only rarely, when crowded out of other places, do they build in trees and shrubs around buildings. Nests around power lines and in electrical substations have created serious fire hazards. Bird droppings are an annoyance wherever sparrows congregate. English sparrows feed primarily on seeds, but they may eat fruits, buds, and emerging plants. They occasionally eat insects, but with little benefit to agriculture.

Red-Winged Blackbird

There are several species of blackbirds, but only the red-winged blackbird and the common grackle are numerous enough to be pests in Illinois. Red-wings, which nest in marsh areas and heavily vegetated fields such as hayfields or fallow fields, usually lay four eggs and will sometimes raise two broods during the nesting season from April into July. Red-wings feed their young on insects, but these birds are scattered so thinly at this time of year that they have no effect on the overall insect population. Congregating in large flocks after the nesting season, red-wings often feed on sweet corn and field corn during the milk and dough stages, and cause extensive damage to fields in close proximity to their roosting sites.

Red-wings migrate during the winter and may congregate in large flocks of more than a million in several southern Illinois counties. During periods of severe weather when food supplies are limited, they move into livestock feeding operations, where they consume and contaminate large amounts of feed. Flocks of red-wings move from feedlot to feedlot and probably transport livestock diseases from one lot to another, as starlings are known to do. The accumulation of droppings at their roosting sites also creates a medium for the growth of fungal diseases such as histoplasmosis. When the roosts are in evergreen plantations, the trees are soon killed by the accumulation of droppings.

Other Birds

Many other birds are sometimes pests, including the pileated woodpecker (*Dryocopus pileatus* (Linnaeus)), hairy woodpecker (*Dendrocopos villosus* (Linnaeus)), chimney swift (*Chaetura pelagica* (Linnaeus), yellow-bellied sapsucker (*Sphyrapicus varius* (Linnaeus)), purple martin (*Progne subis* (Linnaeus)), grackle (*Quiscalas* spp.) brownheaded cowbird (*Molothrus ater* (Boddaert)), gull (family Laridae); blackbird (family Icteridae), and even the robin (*Turdus migratorius* (Linnaeus)). Color patterns are quite important in identifying most of these birds, and any of the numerous books that include colored pictures are useful for identification. No good general method of control has been developed for these birds. Control methods must be adapted to each situation.

Control Measures

A check must first be made to be sure the birds to be eliminated are not protected by federal, state, or local laws or ordinances. Permits are required to control all bird species in Illinois, with the exception of pigeons, starlings, and English house sparrow. Although many different methods have been used to control starlings, red-winged blackbirds, pigeons, and sparrows, the methods can be grouped into four general classes: (1) construction planning, (2) repelling, (3) trapping, and (4) population reduction. In addition, sanitation is very important. Food and water that are attracting pest birds to the area should be removed or made unpalatable if possible. However, birds such as pigeons or starlings that may only be resting or nesting in an area will not be affected by removal of food and water.

Construction Planning

It is usually impossible to make an entire building bird-proof, but the elimination of roosting or nesting areas at the time of construction can greatly reduce the bird nuisance. The surest way to keep birds off the face of the building is to construct it so that there are no roosting places. This requires cooperation between the control personnel and the architect when a building is being planned. Many new government and privately owned buildings are now being planned with this control measure in mind. For example, where ledges are no more than a few inches wide, light metal such as sheet aluminum can be installed at a 45 degree angle to present a surface on which the birds cannot nest.

Repellents

Various scare devices have been installed on buildings to control birds. Stuffed or papier-mache owls, balloons on long strings, rubber snakes, tinfoil streamers, and many other devices have been tried. Many of these work fairly well for a short time where the bird population is not heavy, but when roosting and feeding space is at a premium, these methods are usually ineffective, and may also disturb customers as well as the general public. Blackbirds can be driven away from cornfields by the use of Avitrol, which must be applied by applicators certified in bird control. Several area applicators have been certified in Illinois for applying Avitrol. The chemical causes distress in a few birds, which then frighten other birds from the field. Avitrol may also be used around feedlots.

Trapping

Trapping has long been a successful method of controlling pigeons. Sparrows, starlings, and blackbirds can also be readily trapped. Pigeons can be captured alive in suitable traps in places such as city parks and on the roofs of buildings. It is not usually practical to use traps that require attention more often than every day or two, hence self-setting cage traps are preferred. A trap should be placed as near to a natural area as possible, usually at ground level, but traps can also be used effectively on flat roofs. Various methods are used to attract birds to the traps, for example, grain is placed in the area for several days to get birds accustomed to feeding in the vicinity before a trap is placed. When the baited trap is put in the area, a few live birds are frequently confined in it to make its presence seem more natural to wild birds. Trapping should be considered only in limited, isolated infestations or on individual buildings. Trapped birds must be destroyed or they will return to the trapping site. Poison gas is a commonly used, humane way of disposing of birds.

Population Reduction

Some cities undertake programs of shooting pigeons and starlings. This work is usually done by the city police or by a local civic group. Shooting serves to kill some birds and to drive off many more. If good results are to be obtained, such a program must be carried on continuously. Pigeons and sparrows can be controlled around feedlots and barns by persistent shooting.

Poisoning is probably the most effective way to control birds. Avicides, however, may be used only if properly registered. Label directions should be closely followed. Toxicants for use in baits include strychnine, Avitrol, and DRC-1339. If urban and rural baiting programs are to be effective, control personnel must first find out what grain the birds will eat. Wheat, oats, corn, barely, rice, and commercial bird seed mixtures can be put out unpoisoned to see which ones attract the birds. Generally, birds in cities will feed on any grain, while birds around farms and feed mills are usually controlled best by introducing a suitable grain that was not available to the birds before baiting operations.

Seeds poisoned with strychnine sulfate or strychnine alkaloid are commonly used. Prebaiting with unpoisoned grain helps to improve bait acceptance. Pigeons are usually poisoned with whole corn to avoid exposing songbirds. Seeds or grain poisoned with these chemicals are quite hazardous when handled or eaten; therefore, extreme care must be taken when they are used. Baits placed above ground level must be contained so that they will not be accessible to children, pets, or livestock. All dead birds should be disposed of by deep burial.

Sparrows frequently roost and nest on beams and other supports under the roofs of large buildings that cannot be closed tightly. In this case, good control can be obtained by placing a supply of poisoned grain in pans or trays fastened in the area. The sides of these pans and trays should be at least 2 inches high so that grain will not fall to the floor. The pans should be large enough so that birds can get into them. This technique usually works well under roofs over outside loading docks and similar places.

Avitrol is a bird control agent that produces distress reactions in some of the birds. The distressed birds frighten the rest of the flock, causing them to leave the area. Few of the birds die. Avitrol is available on several bait materials to permit maximum bait acceptance under individual conditions. The baits are diluted with grain of the same size, form, and kind. Whole corn bait is suitable for pigeons, while smaller grain and chopped or pelletized baits are better for sparrows and starlings. Avitrol is toxic to any birds ingesting enough of it, so it should be used carefully to protect desirable species.

DRC-1339, available commercially under the trade name Starlicide, is a compound highly toxic to starlings and blackbirds, but relatively nontoxic to mammals, sparrows, and pigeons. It is a slow-acting poison that shows very little activity as a secondary poisoning agent. Baits are made by diluting the concentrated chemical and applying it to suitable bait materials, such as poultry pellets, rolled barley, or cracked corn. The bait should be used in such a manner that poultry and mourning doves are not exposed, because these species are highly susceptible to DRC-1339.

Once it has been ascertained where birds are roosting, resting, or nesting, perches containing a contact pesticide can be installed. The Rid-A-Bird perch, which is a metal container with a wick surface, holds a liquid contact toxicant that is picked up on the feet of birds landing on it. Sparrows and starlings grasp a perch and pigeons slide on landing and walk flat-footed, so select an appropriate perch with these behavior traits in mind. The toxicant is hazardous to all birds, animals, and humans; therefore, only experienced personnel should install the perches. Only toxicants registered for use on the perches should be used. Label directions for placement, installation, and servicing should be closely followed. These perches should not be used in trees or shrubs. Dead birds should be picked up as quickly as possible to reduce any hazard of secondary poisoning.

Special Control Measures for Woodpeckers

Woodpeckers damage the wooden portions of buildings and disturb occupants with their pecking or drumming. Male woodpeckers, which drum during courtship and to define territories, select drumming sites for their resonance. Wooden shingles, especially cedar shakes, eaves, downspouts, and even television antennas are frequently selected. Woodpeckers rarely peck on buildings for insects infesting the wood, except where insects pupate in the folds in some types of siding. As a matter of fact, drumming sites are often free of insects. Drumming is usually the work of a single woodpecker.

Several techniques have been used to prevent drumming, although they are not effective in every case. Strips of aluminum foil 2 to 3 inches wide and 3 feet long hung from the eaves of fascia board have been used successfully. These strips should be left in place for several weeks to discourage woodpeckers. A 10-percent solution of pentachlorophenal oil can be applied to wood, but should be done cautiously because the oil may stain some surfaces. Another technique is to screen off the affected part of the building with chicken wire or nylon netting. Destruction of woodpeckers should be considered only if drumming cannot be prevented. However, woodpeckers are a protected species, and an appropriate permit has to be obtained. The birds can then be trapped, using a wood-base trap baited with suet and secured to the building. With a permit, woodpeckers can also be shot.

DISPOSING OF SPRAY TANK WASTE

Cesar Fernandez, F.W. Slife, and M.A. Cole

The disposal of dilute solutions of pesticides has not been a major problem for the Illinois farmer. He has been able to dispose of these solutions by spraying them on land or crops for which they have label clearance. With the rapid increase in custom application, however, interest in disposal of spray tank rinse and machine washings has increased. Most custom applicators apply more herbicides than insecticides. Even though only a few herbicides are widely used, a disposal system is needed for these dilute solutions since the applicator must rinse his spray tank when changing treatments.

In 1977 the Agronomy Department in cooperation with the Department of Agricultural Engineering initiated a project for possible disposal systems. This work is partially supported by the Illinois EPA. At the same time a project on pesticide container disposal was started at Southern Illinois University also partially supported by the Illinois EPA.

Spraying pesticides on soil is the best possible disposal system. The soil is alive with hundreds of different kinds of organisms, many of which can contribute to the complete breakdown of pesticides. In addition, the soil has the capacity to hold most pesticides near the surface so that they remain in the area of maximum soil organism activity. The major difficulty in the soil disposal system is fluctuating rainfall. Potential leaching of some pesticides under high rainfall conditions can occur, and under prolonged dry periods microorganism activity declines rapidly, slowing down the degradation process. Under these latter conditions small amounts of pesticide can be carried over into the next growing season.

We have been considering ways to improve the soil disposal system, concentrating on herbicides because of their widespread custom application. We are working on a digestion system where the environment is supplied for maximum growth of soil microorganisms.

In our system we use a tank that contains water mixed with a small amount of soil to provide a source of microorganisms. The mixture is then aerated to add oxygen for the aerobic microorganisms. The next step is to feed the organisms to increase the population and maintain growth. We have not arrived at a proper formula, but corn and soybean meal have been used in the preliminary studies.

Using the tank system we were able to degrade Lasso and Sutan to very low levels in a 3-week period. Although atrazine degraded slower than Lasso or Sutan, this procedure for degradation appears to be much faster than the ordinary soil system.

We have yet to study the rate of degradation of mixtures of compounds, but this will be undertaken soon. The system is somewhat fragile in that very high concentrations of certain herbicides will kill or depress activity of the microorganisms. We believe that we can, with further work, establish maximum amounts of rinsate that can be added to the digestion system at any one time.

USED PESTICIDE CONTAINER PROBLEMS

J.K. Leasure

The U.S. Environmental Protection Agency (USEPA) has published its recommendations for the handling of used pesticide containers in the "Federal Register." These expectations have been restated in both federal and state guidelines for pest control operators. The USEPA assumes its guidelines will be followed. But if past performance is any indication, those suggestions which are disregarded may become hard and fast regulations.

The intent of the USEPA in the matter of used pesticide containers is very clear. Group I containers, those that will burn but did not contain heavy metal pesticides, may be burned or buried if done so according to EPA regulations. Group II containers, those that will not burn but did not contain heavy metal pesticides, may be buried or recycled, again if done so according to EPA regulations. Group III containers, those which may or may not be burnable but did contain heavy metal pesticides, may only be triple-rinsed and buried in an approved sanitary landfill or disposed of in a specially approved hazardous materials landfill.

Metal containers of 1, 5, 30, and 55 gallons are not readily burned, and the metal probably should be recycled because there are a lot of these containers. Recycling is possible if the containers are properly rinsed. Containers that are triple-rinsed according to USEPA guidelines can either be recycled or disposed of as any other nonhazardous material in an approved sanitary landfill. Even if properly rinsed, these metal containers may not be reused. If not triple-rinsed, empty metal pesticide containers can legally be disposed of only in a state-approved hazardous materials landfill, such as the one at Wilsonville, Illinois.

It is becoming clear that expectations do not always become reality--and this holds true for pesticide container disposal. The "1976 Pesticide Use Survey" reports that used pesticide containers meet various fates:

Reused on farm	7%
Stored on farm	8%
Buried	18%
Taken to landfill	38%
Recycled	8%
Returned to dealer	16%
Other disposal	5%

The same survey reveals that not all containers are triple-rinsed:

Not rinsed	20%
Rinsed once	30%
Rinsed twice	30%
Triple-rinsed	20%

Other, more local data is also revealing. In Jackson County, Illinois, in 1977, 600 5-gallon used pesticide containers were collected for a project to study the pesticide container disposal problem. After noting the condition of each can and draining and collecting any remaining pesticide in the cans, we concluded that:

1. Less than 40 percent of the containers were rinsed at all.
2. Less than 20 percent were bottom-punctured.
3. The nearly 370 cans that were obviously not rinsed contained an average of more than 2.5 ounces of pesticide per can.
4. Not included in the residual amounts above were the following: one Treflan can containing more than 3.5 gallons, one Lasso can containing more than 4.25 gallons, one 2,4-D can containing more than 1 gallon, and two cans (Treflan, Sutan) containing more than 1 quart each.

Two collection sites in Wabash County, Illinois, were observed. The first site had about 1,500 cans. A sample of those cans revealed that about 45 percent had been rinsed, and about 30 percent had been punched, but most of those punched were top-punched only. Less than 10 percent were bottom-punched. The second site had 3,500 to 4,000 cans, and only about 40 percent showed any evidence of rinsing. Again, about 30 percent were punched, mostly only in the top. Two 5-gallon cans at the first site were full of used cylinder oil. At both sites cans occasionally contained surprising amounts of chemical.

These data are admittedly fragmentary, but persons who have conducted can collections in other counties have told me that they had similar experiences. An attempt is now being made to collect more extensive data on this subject. If it becomes clear that the USEPA rules for disposal of used containers are being disregarded, the possibility of increased regulation must be considered. This could originate in either the federal or the state EPA.

California now has a closed system pesticide handling regulation, which requires the use of approved pesticide transfer equipment. The equipment accepts a whole can, transfers the chemical to the sprayer tank, rinses the can, transfers the rinse water to the sprayer tank, and then releases a rinsed can. Various methods cost from $670 to $3,000, depending on the versatility of the equipment and the speed of operation. Here in the Midwest separate can crushers that rinse empty metal containers and crush them for recycling are being marketed. These crushers cost from $1,300 to $3,000.

Additional regulations requiring the use of such equipment could easily be written. It is up to all of us to take the problem seriously and work together to ensure compliance with existing regulations if we wish to avoid more stringent ones.

HERBICIDES FOR ZERO-TILL ROW CROP PRODUCTION

G.E. McKibben

Herbicides are one of the major factors in determining the success of zero-tillage row crop production systems. Herbicides used for zero-till corn grown in sod, soybean stubble, and cornstalks, and soybeans grown in cornstalks, tall fescue, and wheat stubble at the Dixon Springs Agricultural Center are discussed below. Not all of the examples of herbicide combinations have label clearance, but the examples do indicate the potential of the herbicide for providing satisfactory weed control with resultant good crop yields. These examples are for illustrative purposes and do not exhaust the arsenal available to applicators and producers.

Zero-Till Corn

Usually when corn is planted in tame grass sods, a combination of Paraquat plus a surfactant and atrazine will provide adequate vegetative control. However, occasionally this treatment is inadequate, as was the case in 1976. The application of 1 pint of Roundup about two weeks before planting, plus application of the Paraquat-atrazine combination at planting, would have produced yields comparable to those from a conventional or plow-plant seedbed (Table 1). This second method of treatment should also be considered where difficulty has been experienced in controlling orchard grass.

When alfalfa makes up a part of the sod, a postemergence treatment of Banvel or 2,4-D when the corn is 4 to 6 inches high, in addition to a preemergence treatment with Paraquat and atrazine, will usually control the alfalfa. If the sod contains red clover, consider increasing the preemergence rate of atrazine by 1 pound of product used in conjunction with Paraquat. The red clover may respond somewhat more slowly than the grass, but control will usually be complete.

It is relatively easy to plant zero-till corn in soybean stubble because residue is limited and the soil is usually in excellent physical condition. Rotation, even the limited one of soybeans and corn, probably has some advantage for weed and disease control as well as for yield. Table 2 gives examples of herbicides providing satisfactory weed control in 1976 and 1977.

Zero-till corn in cornstalks is also feasible, but herbicide combinations that will discourage the buildup of foxtail and panicum problems should be used. If foxtail and panicum are well established at planting, the use of Roundup to kill these plants by translocation to the root, as well as the use of other residuals such as Lasso and atrazine for the control of any new seedlings may be necessary. If one-half of the normal rate of atrazine were replaced with Princep, the period of control for these two wild grasses would be extended even further. Table 3 gives examples of herbicide combinations providing satisfactory weed control. Early application of Roundup (2 weeks before planting) at 1 to 2 pints per acre might be considered as planting time approaches in those years when panicum and foxtail are well established and growing in the stalk residue.

Table 1. Herbicide Treatments for Plow-Plant Corn and for Zero-Till Corn in Tame Grass Sods

Herbicide treatment	Yield, bu./A. 1976[a]	1977[b]
Plow-plant, 2 1/2 lb. 80W atrazine	149.2	145.2
1 pt. Roundup (2 weeks before planting) 1 qt. Paraquat + surfactant (8 oz./100 gal.) 2 1/2 lb. 80W Aatrex	140.1	133.9
1 qt. Paraquat + surfactant (8 oz./100 gal.) 2 1/2 lb. 80W Aatrex	104.4	138.7
Check (no herbicide)	1.8	49.6
1 pt. Roundup (2 weeks before planting) 1 pt. Paraquat + surfactant (8 oz./100 gal.) 2 1/2 lb. 80W Aatrex	...	155.1
2 qt. Roundup 2 1/2 lb. 80W Aatrex	135.2	...

[a]Planted April 19. Variety: Pioneer 3368 A and 3369 A.
[b]Planted May 2. Variety: Pioneer 3369 A.

Table 2. Herbicide Treatments for Plow-Plant Corn and for Zero-Till Corn in Soybean Stubble

Herbicide treatment	Yield, bu./A. 1976[a]	1977[b]
1 qt. Paraquat + surfactant (8 oz./100 gal.) 2 1/2 lb. 80W Aatrex	168.9	158.0
2 qt. Roundup 2 1/2 lb. 80W Aatrex	180.3	...
1 pt. Roundup (2 weeks before planting) 1 qt. Paraquat + surfactant (8 oz./100 gal.) 2 1/2 lb. 80W Aatrex	154.8	175.5
Plow-plant, 2 1/2 lb. 80W Aatrex	168.9	148.5
1 qt. Roundup (2 weeks before planting) 1 qt. Paraquat + surfactant (8 oz./100 gal.) 2 1/2 lb. 80W Aatrex	178.7	...
Check (no herbicide)	144.9	146.6

[a]Planted May 11. Variety: Pioneer 3369 A and 3184.
[b]Planted April 27. Variety: Pioneer 3369 A.

Table 3. Herbicide Treatments for Zero-Till Corn in Cornstalks

Herbicide treatment	Yield, bu./A. 1974[a]	1975[b]
Check (no herbicide)	74	67
1 qt. Paraquat + surfactant (8 oz./100 gal.) 2 1/2 lb. 80W Aatrex	190	167
1 qt. Paraquat + surfactant (8 oz./100 gal.) 1 qt. Aatrex 4L 1 qt. Princep 4L	190	184
1 qt. Paraquat + surfactant (8 oz./100 gal.) 1 1/4 lb. 80W Aatrex 1 1/4 lb. 80W Princep	166	160
2 qt. Roundup 1 qt. Aatrex 4L 1 qt. Princep 4L	173	173

[a]Planted May 28. Variety: Pioneer 3369 A.
[b]Planted May 28. Variety: Pioneer 3369 A.

Zero-Till Soybeans

Zero-till soybeans in cornstalks may be a feasible alternative to conventional seedbeds in some situations, particularly where good weed control has been achieved in the previous corn crop. Basagran offers a backup for certain broadleaves, and Hoelon, which has an experimental label, may offer a backup as a broadcast, over-the-top treatment for panicum, foxtail, and volunteer corn. If foxtail and panicum are established at planting, consideration should be given to the use of Roundup. Table 4 gives examples of herbicide combinations providing satisfactory weed control.

Zero-till soybeans may be advantageous on certain farms where soybeans should not be planted because of soybean cyst nematode infestations and where renovation of hay or pasture fields for soybeans may cause serious erosion problems. In situations such as this, zero-till in hay or pasture fields might help to maintain the total soybean acreage on the farm and provide a longer interval between soybean crops on the more intensively cropped fields.

Soybeans have been successfully produced in fescue at Dixon Springs in 1976 and 1977. Table 5 gives examples of herbicide combinations providing adequate vegetative control for soybeans planted in a 15-inch row spacing.

It appears that the 1977 yields for zero-till soybeans planted in tall fescue will be comparable to the 1976 yields, and that a pint of Roundup applied two weeks before planting, plus one pint of Paraquat plus a surfactant and 2 pounds of 50W Sencor, has provided satisfactory vegetative control. If the pasture is infested with foxtail, the addition of a wild grass herbicide would be advisable. A row spacing of 15 to 20 inches is desirable. The 2 pounds of 50W Sencor used on this soil type is approximately double that used on a conventional seedbed; no injury was apparent.

Table 4. Herbicide Treatments for Zero-Till Soybeans in Cornstalks

Herbicide treatment	Yield, bu./A. 1974[a]	1975[b]	1976[c]
1. 1 qt. Paraquat + surfactant (8 oz./100 gal.) 2 qt. Lasso 2 lb. 50W Lorox	47.5	44.4	37.9
2. Treatment 1 POST: 1 qt. Basagran	56.7	52.1	28.6
3. 1 qt. Paraquat + surfactant (8 oz./100 gal.) 2 lb. 50W Sencor 2 qt. Lasso	50.7	47.6	38.3
4. Treatment 3 POST: 1 qt. Basagran	...	50.0	39.1
5. 1 qt. Paraquat + surfactant (8 oz./100 gal.) 1 1/2 lb. 50W Sencor 2 qt. Lasso POST: 1 1/3 qt. Hoelon	...	...	71.5
6. 2 qt. Roundup 2 qt. Lasso 2 lb. 50W Lorox	52.2	38.3	48.8
7. Treatment 1 POST: 1 1/3 qt. Hoelon	...	...	52.5
8. Treatment 6 POST: 1 qt. Basagran	...	...	59.8
9. 2 qt. Roundup 2 lb. 50W Sencor 2 qt. Lasso	47.6	25.9	44.2
10. 1 qt. Paraquat + surfactant (8 oz./100 gal.) 2 lb. 75W Surflan 2 lb. 50W Sencor	55.4	47.6	61.7
11. 2 qt. Roundup 2 lb. 75W Surflan 2 lb. 50W Sencor	...	...	64.6
12. Check (no herbicide)	24.8	3.6	25.2

[a]Planted June 10. Variety: Williams. Row space: 30 inches.
[b]Planted June 4. Variety: Williams. Row space: 30 inches.
[c]Planted May 12. Variety: Williams. Row space: 30 inches.

Table 5. Herbicide Combinations for Zero-Till Soybeans (Inoculated Williams), Planted in Tall Fescue Sod, May 10, 1976

Herbicide treatment	Yield, bu./A.
2 qt. Roundup (4/22) 1 qt. Paraquat + surfactant (8 oz./100 gal.) 2 lb. 50W Sencor	47.0
1 qt. Roundup (4/24) 1 qt. Paraquat + surfactant (8 oz./100 gal.) 2 lb. 50W Sencor	43.8
1 pt. Roundup (4/22) 1 qt. Paraquat + surfactant (8 oz./100 gal.) 2 lb. 50W Sencor	45.5
Check (no herbicide)	15.5

Planting zero-till soybeans in wheat stubble is a well-established practice in Illinois. Several herbicides and herbicide combinations are available for weed control in this situation. In 1977 a new combination, Roundup, Lasso, and Lorox, became available. Roundup should be used where there is well-established panicum, foxtail, or smartweed in the stubble at planting. Hoelon, which had an experimental permit in 1977, should add a new dimension to weed control in double crop soybeans. As a postemergence, over-the-top herbicide for fall panicum and foxtail control, Hoelon is applied at the four-five leaf stage of the grasses. Other combinations have the potential for controlling given weed problems. Table 6 gives examples of herbicide combinations providing satisfactory weed control for zero-till soybeans in wheat stubble.

Compared with the residual herbicide rates for conventional seedbeds, the rates in zero-till situations must be higher in order to provide a comparable degree of weed control. Fortunately, these higher rates usually pose no problems to the present or future crop. With contact herbicides, a sufficient volume of water should be used to wet the above-ground parts of the live vegetation. Consideration of these two points should reduce the number of failures reported in vegetative control in zero-till culture.

Table 6. Herbicides for Zero-Till Soybeans (Amsoy 71) Planted at 20-Inch Row Spacings in Wheat Stubble, July 12, 1976

Herbicide treatment		Yield, bu./A.
1.	Check (no herbicide)	1.7
2.	1 qt. Paraquat + surfactant (8 oz./100 gal.) 2 lb. 50W Lorox, 2 qt. Lasso	32.5
3.	Treatment 2 POST: 1 qt. Basagran + surfactant	26.7
4.	Treatment 2 POST: 1 1/3 qt. Hoelon	39.0
5.	1 qt. Paraquat + surfactant (8 oz./100 gal.) 2 lb. 50W Sencor, 2 qt. Lasso	37.8
6.	2 qt. Roundup, 2 lb. 50W Sencor, 2 qt. Lasso	36.2
7.	1 qt. Paraquat + surfactant (8 oz./100 gal.) 2 lb. 50W Lorox, 2 qt. Dual	47.2
8.	1 qt. Paraquat + surfactant (8 oz.100/gal.) 2 lb. 50W Sencor, 2 lb. 75W Surflan	36.9
9.	2 qt. Roundup, 2 lb. 50W Lorox, 2 qt. Dual	40.5
10.	2 qt. Roundup, 2 lb. 50W Lorox, 2 qt. Lasso	38.6
11.	2 qt. Roundup, 2 lb. 50W Lorox, 2 lb. 75W Surflan	36.2
12.	2 qt. Roundup, 2 lb. 50W Sencor, 2 lb. 75W Surflan	36.9
13.	Treatment 5 POST: 1 qt. Basagran	37.8
14.	Treatment 6 POST: 1 qt. Basagran	43.9
15.	Treatment 10 POST: 1 qt. Basagran	34.2
16.	2 qt. Roundup, 1.875 lb. 80W Modown, 2 qt. Lasso	40.2

MAINTAINING APPLICATION PRECISION WITH HIGH-CAPACITY SPRAYERS

L.E. Bode, B.J. Butler

High-capacity flotation sprayers were initially used for application of fertilizers. High flotation meant faster application, heavier loads, less soil compaction, and additional days for application because of being able to work in wet fields. First established by the fertilizer industry, the concept of flotation quickly expanded to the application of pesticides and fertilizer-pesticide combinations. The application of pesticides using high-capacity flotation sprayers, however, requires more precise control than application of fertilizers, so flotation operators must be aware of this and other differences.

NOZZLE SELECTION AND USE

Spray nozzles are the most important part of any spraying system. Nozzles control the volume of pesticide applied, the uniformity of application, the thoroughness with which the surface is covered, and the amount of drift that occurs. Although several types of spray nozzles are available, most high-capacity sprayers are equipped with flooding flat-fan nozzles. Boom-mounted flooding nozzles on 40- to 120-inch centers allow wide swaths to be sprayed with only a few nozzles. With relatively large orifices few clogging problems occur. When properly mounted and operated at pressures of 8 to 25 pounds per square inch (psi), flooding nozzles are excellent for reducing drift.

Many spray characteristics affect the accuracy and uniformity of application. Surface tension, density, and viscosity affect the flow rate and the spray distribution pattern. Surface tension generally has only a minor effect. The density of the spray solution, especially when pesticides are applied in fertilizers, affects the flow rate through the nozzle. Flow rate varies inversely with the square root of the fluid density.

Nozzle manufacturers' catalogs have nozzle tables listing each nozzle's flow rate for water in gallons per minute (gpm) at various pressures. Such catalogs generally include conversion factors to correct for density.

Example: To apply a fertilizer having a density of 12 lb./gal., using an F30 or a K30 nozzle: The catalog listing for the flow rate for the F30 or the K30 nozzle at 20 psi is 4.2 GPM, and the conversion factor for 12 lb./gal. of material is 0.83.

GPM of fertilizer at 20 psi = 4.2 x 0.83 = 3.5 GPM

An increase in viscosity results in a reduction of the flow rate because of friction within the liquid, the nozzle, and its orifice. High viscosity is a major problem when applying pesticides in fertilizer suspensions. Diluting the mixture with a small quantity of water (usually 10 percent) lowers the viscosity for ease of handling and application. Tests by the Tennessee Valley Authority show that for uniform application the viscosity of a suspension should be less than 1,000 centipoises at 70°F. , which is equivalent to SAE 50W oil at 70°F. When a highly viscous solution is sprayed through flooding nozzles, a heavier concentration of material tends to occur on the edge of the spray pattern. Decreasing the viscosity by dilution reduces this tendency.

Other factors affecting uniformity of application are nozzle pressure, nozzle height, orifice size, nozzle spacing, and nozzle orientation.

Pressure affects application in several ways. It influences droplet size, nozzle flow rate, spray angle, and pattern uniformity. Increases in pressure decrease droplet size more rapidly in flooding nozzles than in regular flat-fan nozzles. At low pressures, flooding nozzles produce large droplets; at high pressures, these nozzles actually produce smaller droplets than do regular flat-fan nozzles at an equivalent flow rate. For good drift control, flooding nozzles should be operated below 25 psi of pressure.

Operators of flotation equipment sometimes attempt to correct gallonages per acre by varying the pressure. Minor flow corrections for such things as nozzle wear can be made by changing the pressure, but major changes require a different nozzle tip size, because doubling the pressure does not double the gallons per acre. The nozzle flow rate is proportional to the square root of the pressure; therefore, to double the application volume, the pressure must be increased four times. For example, if the flow from a K30 nozzle at 15 psi = 4.0 gpm, the pressure must be increased to 60 psi to double the flow to 8.0 gpm.

The spray distribution patterns of flooding nozzles vary greatly with changes in pressure (Figure 1). At low pressures, flooding nozzles generally have a fairly uniform pattern across the swath, but at high pressures the pattern becomes heavy in the center with a tapered edge effect. Therefore, to obtain an acceptable distribution pattern, the pressure range for flooding nozzles should be limited to 8 to 30 psi.

The width of the spray pattern is influenced by pressure. The effects of pressure on pattern width (spray angles) for K30 and KLC108 flooding nozzles are shown in Figure 2. At 10 psi the pattern width for the K30 nozzle is 9.5 feet. As pressure increases to 30 psi, the width increases to 13.5 feet. Pattern widths from nozzles with higher flow rates vary even more. The pattern width for the KLC108 nozzle in Figure 2 ranges from 21 to 33 feet as the pressure increases from 10 to 30 psi. Automatic metering systems are used to maintain a constant gallonage per acre by varying the nozzle pressure, regardless of the travel speed. With such systems, flooding nozzles must have the proper overlap in order to maintain a fairly uniform pattern with the variation in spray width as the pressure changes.

Nozzle height is critical in obtaining uniform application. Height is especially important when using fertilizer nozzles with a high flow rate at 10-foot spacings. A KLC72 nozzle mounted vertically and spraying at 20 psi will decrease its pattern width by over 6 feet when the nozzle height is reduced from 36 to 25 inches above the ground. Don't forget that the nozzle pattern width is 15 to 20 percent less when traveling 12 to 16 mph than when stopped. Once the proper nozzle height has been determined, the travel speed must be selected according to field conditions to obtain uniform application and to keep the boom from whipping back and forth or bouncing up and down. For most applications, maximum travel speeds of 12 to 16 miles per hour should be maintained, rather than the speeds of 18 to 22 mph that are often used.

So that adjustments can be made for pattern variability due to pressure, height, and spacing, the recommended nozzle arrangement for applying pesticides is shown in Figure 3. With this arrangement, the nozzles are spaced on 40- to 80-inch centers. The spray pattern should be double coverage, or 100 percent overlap so that individual nozzle patterns reach the center of the pattern of each adjacent nozzle. With double coverage, any uneven coverage from individual nozzles can be partly compensated for by spray from adjacent nozzles. Proper overlap can be obtained by raising or lowering the boom for each pressure and nozzle size used. Boom height frequently is not changed during pressure changes from automatic metering systems reacting to changes in ground speed. In such cases we feel that speed should not be varied more than $\pm$ 25 percent.

Flooding nozzles can be mounted vertically to spray back, horizontally to spray down, or at any angle between vertical and horizontal. Tests have shown that the most uniform application from flooding nozzles is obtained when the nozzles are installed at a 30- to 45-degree angle above the horizontal axis. Figures 4 and 5 compare individual and overlapped spray patterns from a K20 nozzle when mounted horizontally and 30 degrees above horizontal. When the spray is directed vertically down to the ground, there can be considerable variation in the distribution, with a tendency for heavy concentrations at the edges of the spray pattern (Figure 4). Rotating the nozzles 30 to 45 degrees from horizontal will result in a more uniform pattern over a pressure range of 8 to 30 psi. For uniform distribution over a range of pressures, nozzles should be mounted to obtained double coverage at the lowest operating pressure (Figure 5).

Figures 6 and 7 indicate the decrease in accuracy of spray distribution when flooding nozzles are spaced on 10-foot centers. With a pressure change from 30 to 10 psi the patterns are not sufficiently uniform for applying pesticides.

The RA Raindrop nozzle has recently been introduced as a drift reduction nozzle. For flotation equipment, the Delavan Corporation recommends that the nozzles be mounted with a rotation of 45 to 90 degrees from the vertical axis and at 60-inch spacings. When operated within a pressure range of 20 to 50 psi, the nozzle delivers a wide-angle, hollow cone spray pattern, and produces, fewer small drops than the flooding nozzle. However, from a drift control standpoint we prefer to see the Ra nozzle mounted at no more than a 45-degree angle, which gives a satisfactory distribution pattern.

Nozzle tips must be selected according to the spray coverage and application volume desired. The following formula can be used to select a nozzle for a particular application:

$$GPM = \frac{GPA \times MPH \times W}{5,940}$$

where:

GPM== gallons per minute of output required from each nozzle

GPA = gallons per acre desired

MPH = miles per hour travel speed

W = spray width per nozzle or nozzle spacing in inches

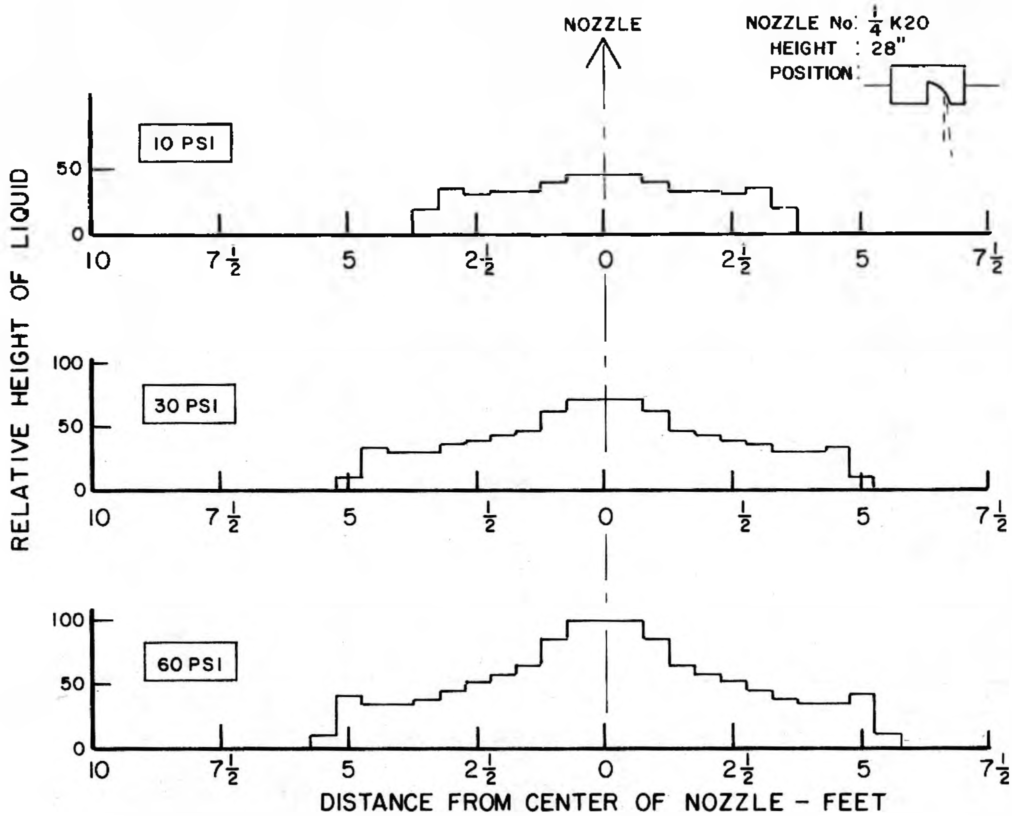

Figure 1. Spray distribution patterns from K20 flooding nozzles at 10, 30, and 60 psi.

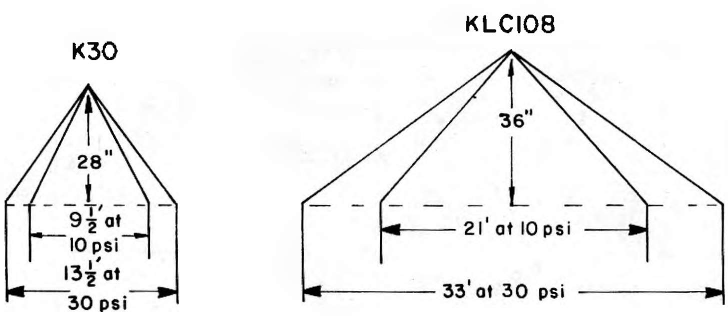

Figure 2. Effect of pressure on swath width from K30 and KLC108 flooding nozzles at 10 and 30 psi.

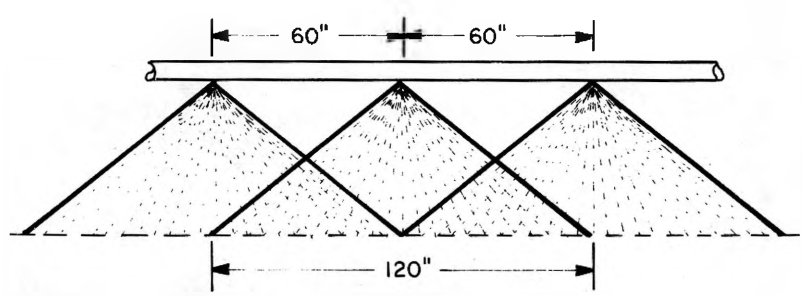

Figure 3. Correct nozzle arrangement for double coverage or 100 percent overlap.

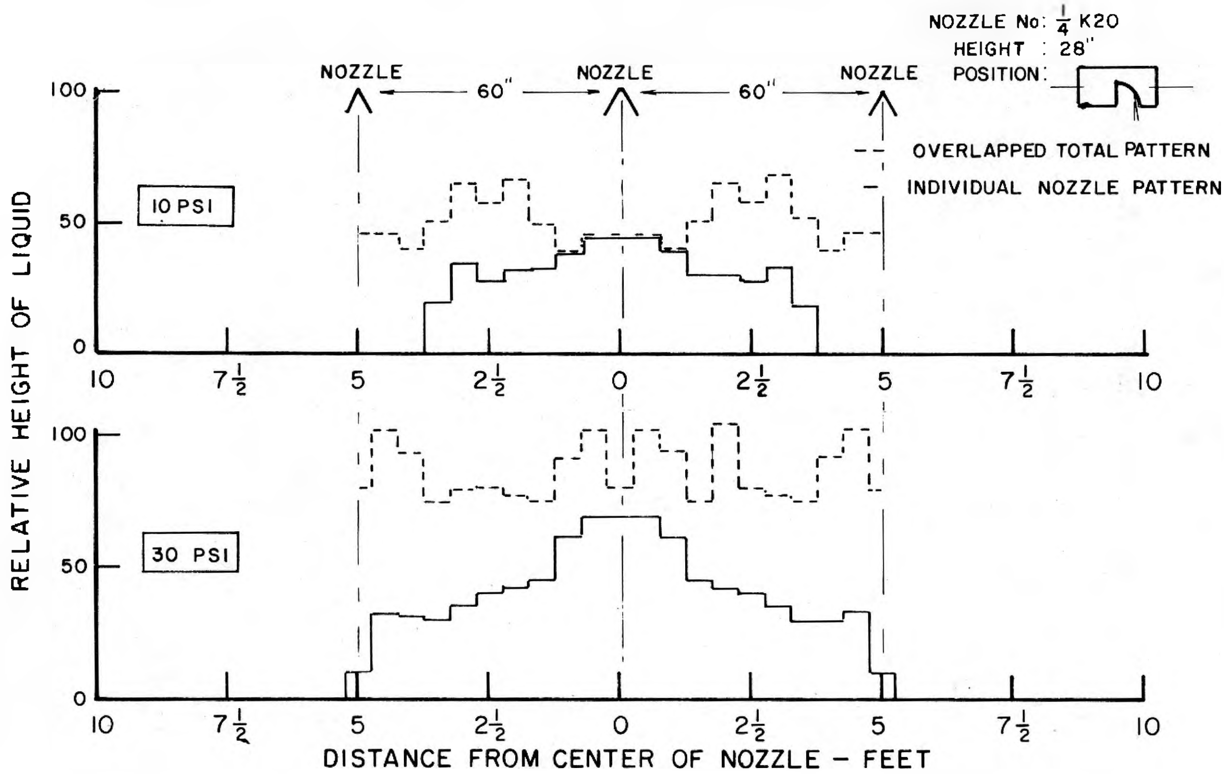

Figure 4. Individual and overlapped total spray patterns from K20 nozzles at 10 and 30 psi. Nozzles spaced on 60-inch centers.

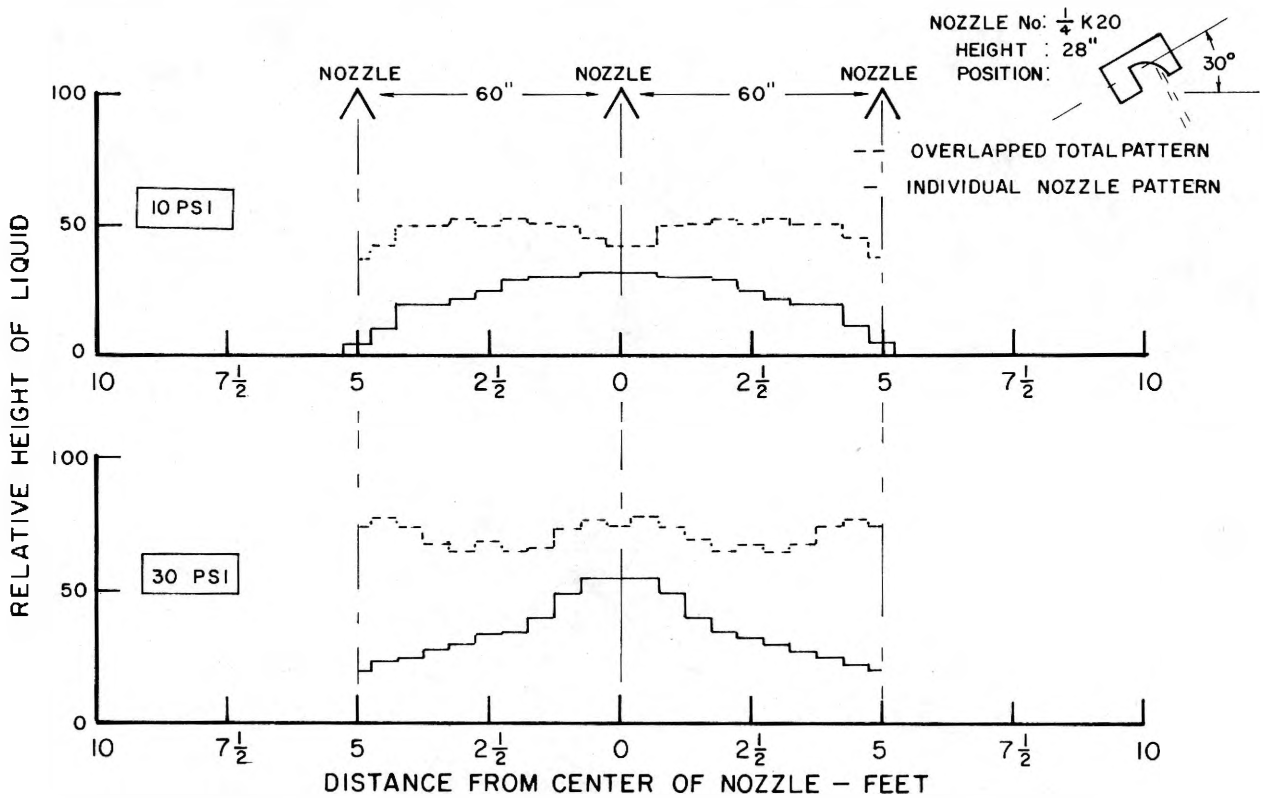

Figure 5. Individual and overlapped total spray patterns from K20 nozzles at 10 and 30 psi. Nozzles mounted 30 degrees above horizontal at 60-inch spacings.

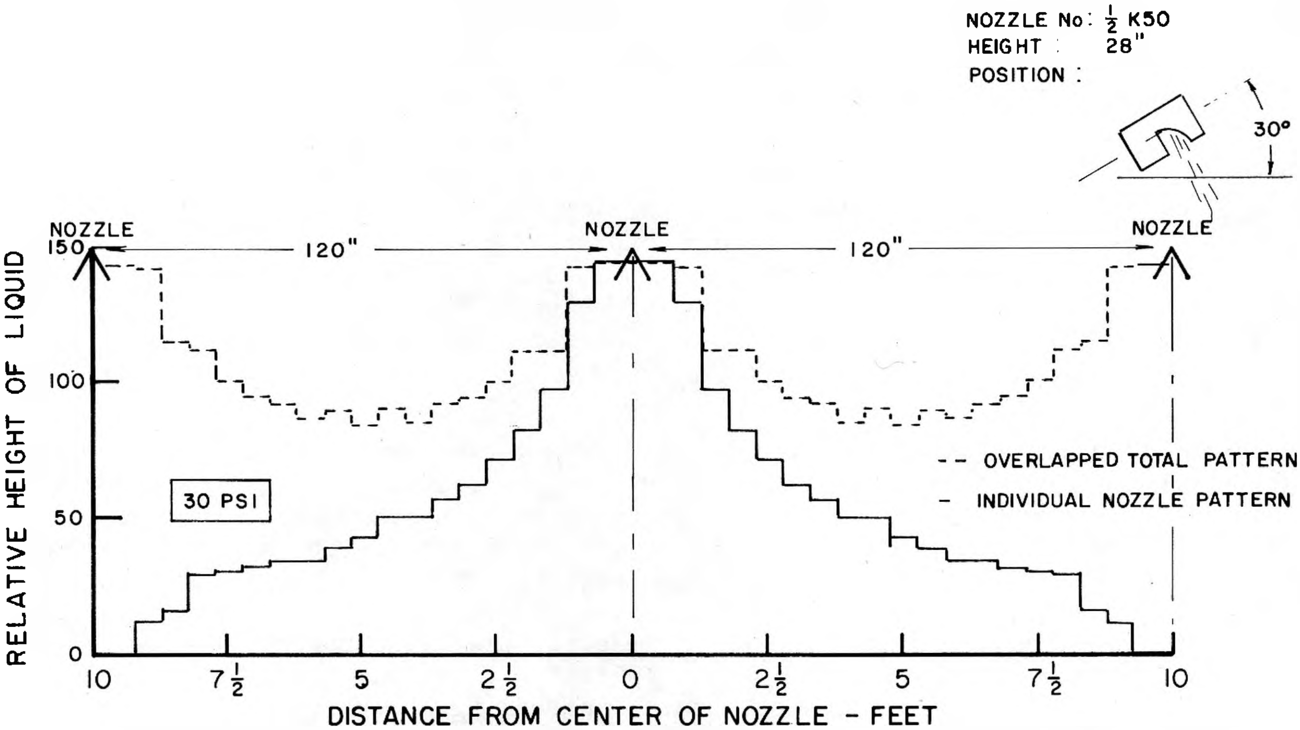

Figure 6. Individual and overlapped total spray patterns from K50 nozzles at 30 psi. Nozzle mounted 30 degrees above horizontal at 120-inch spacings.

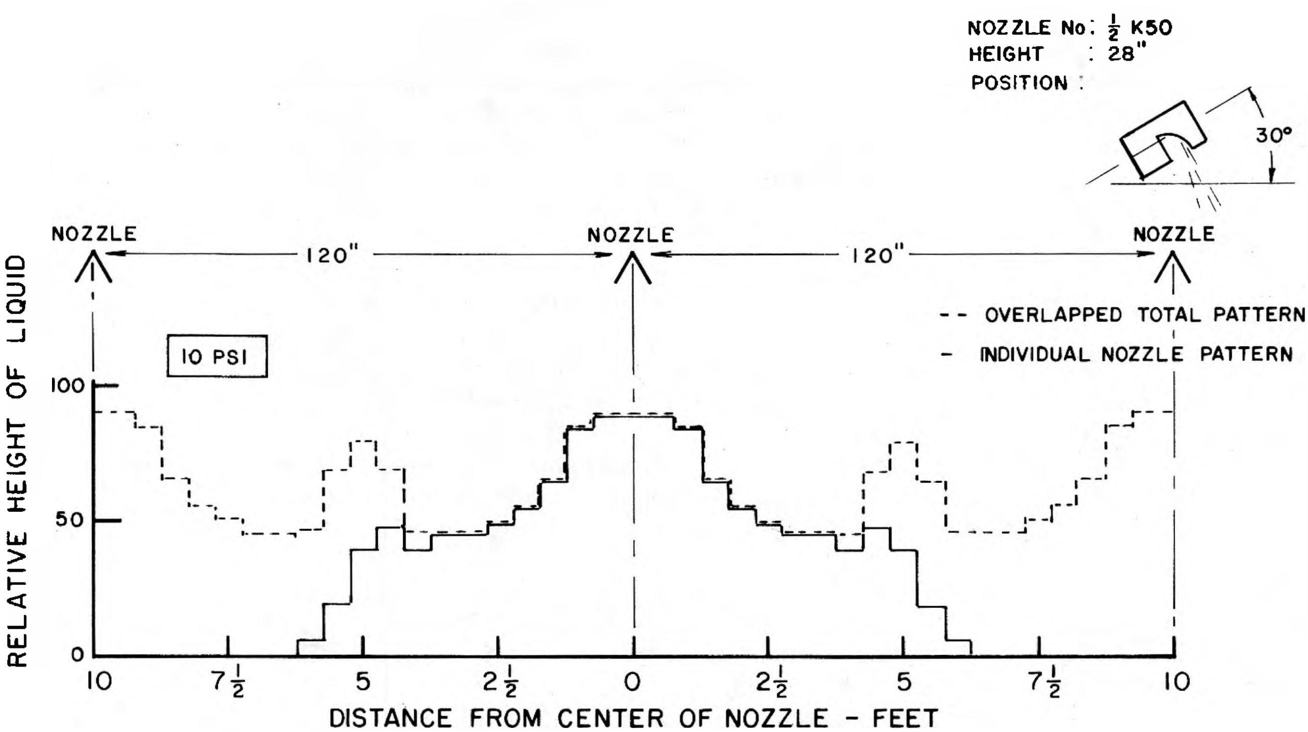

Figure 7. Individual and overlapped total spray patterns from K50 nozzles at 10 psi. Nozzles mounted 30 degrees above horizontal at 120-inch spacings.

Example: To apply 20 GPA at 12 MPH with flooding nozzles on 60-inch spacings:

$$\text{GPM per nozzle} = \frac{\text{GPA x MPH x W}}{5{,}940} = \frac{20 \text{ x } 12 \text{ x } 60}{5{,}940} = 2.4$$

From a nozzle manufacturer's catalog, select tips that apply the required flow in the middle of the recommended pressure range of 8 to 30 psi. After installing the selected nozzle tips, the pressure required to obtain the desired flow rate can be determined by collecting the output from individual nozzles and adjusting the pressure until the desired rate is produced. Depending on nozzle capacity, 1- to 10-gallon containers can be used to collect the nozzle spray solution.

APPLICATION SYSTEMS

Flotation sprayers generally have some type of metering system that attempts to maintain a constant spray volume per acre over a range of travel speeds. Systems now in use, such as ground-driven piston pumps, electronic feedback control systems, and various centrifugal-pump arrangements, vary nozzle pressure with changes in travel speed to keep the gallons per acre constant.

To regulate the flow in proportion to the travel speed, the nozzle pressure must vary by the square of the speed. If an applicator is traveling at 8 mph and is operating at a pressure of 20 psi at the nozzle, increasing the speed to 16 mph requires raising the pressure at the nozzle to 80 psi. Keep in mind that a fourfold range in pressure drastically changes the droplet size, pattern width, and distribution pattern. For uniform application, constant speed should be maintained as much as possible even when using controlled metering systems.

When flooding nozzles are used, variations in speed should always be limited in order to maintain the nozzle pressure within the recommended range of 8 to 30 psi. For example, if the calibrated set point for boom pressure is 15 psi, the permissible variation in speed is ± 25 percent of the calibrated speed. On the other hand, if the calibrated set point is 25 psi, speed variation is limited to + 10 percent and -40 percent. This higher pressure setting allows turning at the ends of the field at lower speeds while still obtaining a good pattern when the boom is turned back on after making the turn.

Weed control is often poor at the edge of the field when there is no overlap from the end nozzle on the fist pass around the field. One solution is to install a separate, off-center nozzle on the end of the boom. That nozzle can be operated by a manual or electric valve during the first round and then shut off during application over the rest of the field. Another method is to decrease travel speed until the resulting pressure drop reduces the pattern width to single coverage with no overlap. This procedure eliminates the edge effect, but results in an uneven spray pattern across the boom.

Crop damage can occur if the nozzles are allowed to drip during turns or when the sprayer is stopped for refilling or other reasons. To avoid dripping, high capacity, diaphragm nozzle check valves should be used on each nozzle. These valves give satisfactory results with minimum maintenance. When calibrating the nozzle flow rate, remember to account for the pressure drop across the valve: a 5-psi check valve requires 25 psi at the boom in order to have 20 psi at the nozzle.

Marking swaths is a major problem when applying pesticides with high-speed, high-capacity flotation sprayers that have wide booms. At high speeds and long distances from the mark, achieving accuracy is so difficult that overlaps and skips can easily occur. At present, marking systems rely on the operator's skill in sighting a particular mark; sun glare, cross tillage, and simple lack of visual perception or decreased vision at night are sources of error.

Marking systems currently used include flagmen, automatic flaggers, mechanical disk markers, dyes, soaps, foams, and electric guidance systems. The most widely accepted system used by flotation operators seems to be the foam marker. Current research and development activities are aimed at developing new marking systems that use recent electronic advances, such as light-sensing, rotating lasers and radio-controlled guidance systems.

The AgNav system recently introduced uses radio signals to track and guide the operator by means of a continuous display on the dashboard. The concept has tremendous potential for reducing overlap and skips, but operator experience will be required to determine electronic reliability under field conditions.

DRIFT AND COVERAGE

Preplant and preemergence applications of herbicides and soil-applied insecticides do not require a large number of droplets per square inch for good pest control. Therefore, high pressures for maximum droplet breakup are not needed. Emphasis should be placed on using only enough pressure to obtain good spray patterns. Lower pressures result in larger drops that are less likely to drift if wind gusts occur.

Applicator experience indicates that 15 to 20 gallons of spray solution per acre gives sufficient coverage for most preplant and preemergence herbicides when applied in calm wind conditions. To apply pesticides in 8- to 10-mph winds with greater safety, good applicators use nozzles with higher flow rates to apply 25 to 40 gallons of spray solution at a spraying pressure of 8 to 15 psi. Increasing the spray volume for higher wind speeds should be done by using nozzles with higher flow rates, not by increasing the spray pressure.

The University of Illinois has initiated a series of drift measurements, using high-volume flooding nozzles. Initial measurements of drift deposits compared a KLC18 nozzle mounted at a height of 40 inches with TK4 and 8002 nozzles mounted 20 inches above the ground. Although the amount of spray deposited outside the swath by the KLC18 nozzle (23 to 38 percent) was larger than deposits from the TK4 and 8002 nozzles (5.5 to 28.5 percent), most of the downwind deposits were collected within 20 feet of the swath. There was very little difference among the three nozzles in terms of the downwind distance required to reduce the spray volume to 1 percent of the application volume.

Spray thickeners can be used to reduce spray drift. New long-chain polyvinyl polymers that prevent the formation of many of the small droplets are available as thickening agents. The addition of 4 to 8 ounces of the thickener per 100 gallons of spray solution will drastically reduce the amount of drift from flooding nozzles. No special equipment is required to use these thickeners, but they must be mixed according to directions.

RULES AND REGULATIONS FOR [illegible] E[illegible] THE ILLINOIS STATE PLAN

Juett C. Hogancamp

The Federal Environmental Pesticide Control Act (FEPCA) of 1972 substantially amended the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) of 1947. FIFRA was administered by the U.S. Department of Agriculture until authority was transferred to the U.S. Environmental Protection Agency in 1970. FEPCA must be implemented by October 21, 1977.

The Illinois Department of Agriculture was designated by the Governor of Illinois on October 18, 1973, to be the lead agency to implement FIFRA. The Illinois Department of Public Health is a cooperating agency and is responsible for administering the Illinois Structural Pest Control Act of 1975. In addition the Illinois Cooperative Extension Service will have the lead role, pursuant to an Intrastate Service Agreement with the Illinois Department of Agriculture, for the statewide pesticide applicator certification training program, excluding training in Category 7 and Mosquito Control.

This responsibility includes preparation and administration of training materials, and distribution of training materials.

The Rules and Regulations are as follows:

ARTICLE I: Definitions

Regulation 1.1. "Agricultural Commodity" means any plant, or part thereof, or animal or animal product, produced by a person (including farmers, ranchers, vineyardists, plant propagators, Christmas tree growers, aquaculturists, floriculturists, orchardists, foresters, or other comparable persons) primarily for sale, consumption, propagation, or other use by man or animals.

Regulation 1.2. "Certification" means the recognition by a certifying and/or licensing agency that a person in the applicator category is competent and thus authorized to purchase, use, or supervise the use of restricted use pesticides.

Regulation 1.3. "Commercial Pesticide Applicator for Hire" means a person who personally, or by his agent, owns or operates a custom application business or who purchases, uses, or supervises the use of restricted use or general use pesticides to the property of another for hire or as part of his job responsibility. (Same as Custom Applicator)

Regulation 1.4. "Commercial Pesticide Applicator Not for Hire" means a person who personally, or by his agent, purchases, uses, or supervises the use of restricted use pesticides to his property or the property of his employer but is not a government employee.

Regulation 1.5. "Commercial Pesticide Operator for Hire" means a person who is employed or directly supervised by a commercial pesticide applicator for hire or who handles and mixes pesticides, operates pesticides applicating equipment and who disposes of waste, excess materials, and containers. When using restricted use pesticides such person shall be under direct supervision. (Same as Custom Operator)

Regulation 1.6. "Department" means the Illinois Department of Agriculture.

Regulation 1.7. "Grain Handling Facility" means any building, structure or enclosure and its premises where grain is stored and which is regulated under "The Public Grain Warehouse and Warehouse Receipts Act" or the "U.S. Warehouse Act" and/or the "Illinois Grain Dealers Act," or whose product is registered under the "Illinois Commercial Feed Act" of 1961, and shall also include the vehicles used in the transport of grain; to exclude any such facility where processing of grain into products for human consumption occurs, such facility will come under the jurisdiction of the "Structural Pest Control Act" and the Illinois Department of Public Health.

Regulation 1.8. "Person" means any individual, firm, partnership, association, corporation, company, joint stock association, governmental agency or any other organized group of persons whether incorporated or not; and includes any trustee, receiver, assignee, or other similar representative thereof.

Regulation 1.9. "Private Pesticide Applicator" means a certified applicator who purchases, uses or supervises the use of any pesticide which is classified for restricted use for purposes of producing any agricultural commodity on property owned or rented by him or his employer or, if applied without compensation other than trading of personal services between producers of agricultural commodities, on the property of another person.

Regulation 1.10. "Public Pesticide Applicator" means a public employee who exercises direct control over recommending, selecting, use, and application of pesticides to include restricted use pesticides, for use by a state agency, municipal corporation or other governmental agency. He also directly supervises public operators in the use and application of all pesticides.

Regulation 1.11. "Public Pesticide Operator" means a person who is employed by a state agency, municipal corporation or other governmental agency and who is directly supervised by a commercial public applicator of that entity or agency and who operates an engine of motor driven applicating equipment or device and who handles and mixes pesticides, and disposes of waste, excess material and containers.

Regulation 1.12. "Supervision of Under Direct Supervision" means:

1. The continuous physical presence of the certified or licensed supervisor, or;

2. In the absence of the certified or licensed supervisor, clearly legible instructions and/or directions for the handling and application of the pesticide; for the precautions to be taken to prevent injury to the applicator, other persons and/or the environment; for the establishment of direct voice contact with the certified licensed supervisor covering a time period normally adequate to complete the assignment(s). (the pesticide label is part of such instructions and may suffice in those matters which it covers), and;

3. The supervising certified applicator shall be physically present at the site of applications

   (a) if the labeling of the pesticide being applied so stipulates,
   (b) if the non-certified applicator has no prior experience with either the pesticide or the application methodology in use,
   (c) in other situations where required, and ultimate responsibility for the application of restricted use pesticides by a non-certified applicator shall remain with the supervising certified or licensed applicator.

ARTICLE II: Pesticide Restriction

Regulation 2.1. The sale, use or application of sodium fluoroacetate, 1080 (CH_2 $FCOON_a$) and fluoroacetamide, 1081 (FCH_2COHN_2) is prohibited in the State of Illinois, effective July 1, 1972, except where such sale, use or application has received a prior permit from the Director of the Department of Agriculture acting in his jurisdictional area as defined in Section 4 of the "Pesticide Control Law."

> "It is the duty of the Department of Agriculture to enforce the provisions of this Act in the control of pesticides pertaining to the production, protection, care, storage, or transportation of the agricultural commodoties and as the use of pesticides pertain to agricultural equipment".[1]

Regulation 2.2. That the State of Illinois shall enforce all pesticide use restrictions declared by the Federal Environmental Protection Agency.

ARTICLE III: Permits

Regulation 3.1. Application to the Department for a permit to purchase, use and apply sodium fluoroacetate or fluoroacetamide shall describe:

A. The nature of the problem,
B. Areas or facility to be treated,
C. The date or dates of application,
D. The application rate and manner of application,
E. The total quantity of sodium fluoroacetate or fluoroacetamide to be used,
F. Additional information pertinent to the request.

Regulation 3.2. Such permit shall be granted only when a serious rodent problem exists and valid evidence indicates that less toxic rodenticides would not provide effective control.

ARTICLE IV: Vendor Responsiblity

Regulation 4.1. It is the responsibility of any vendor of sodium fluoroacetate or fluoroacetamide to maintain records of all sales and a copy of the permit authorizing the purchase.

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[1]Quoted from Section 4 of the "Pesticide Control Law" as it pertains to the Department of Agriculture.

Regulation 4.2. All vendors of sodium fluoroacetate or fluoroacetamide shall annually submit to the Department issuing the permit a report on or before November 1 of each year the amount of sodium fluoroacetate or fluoroacetamide sold since last filing date.

ARTICLE V: Exemptions

Regulation 5.1. Persons specifically exempted from certification licensing under the Act include (1) persons conducting laboratory type research involving restricted use pesticides; and (2) doctors of medicine and doctors of veterinary medicine applying pesticides as drugs or medication during the course of their normal practice.

ARTICLE VI: Testing, Certification and Licensing

Regulation 6.1. Persons may make application to the Department to become certified to purchase and apply restricted use pesticides or to apply general use pesticides for hire as a commercial applicator. Persons may also make application to the Department to become license as a commercial operator to apply pesticides under the direction of a commercial applicator. Applicators and operators can receive certification or licensing in one or more of the following categories. Categories are numbered as they appear in the State Plan for Pesticide Control.

1. Agricultural Pest Control

(a) Plant

1. Field Crop Pest Control

This subcategory includes commercial applicators using or supervising the use of restricted or general use pesticides in production of agricultural field crops including but not limited to field corn, soybeans, feed grains and forage as well as on grasslands and non-crop agricultural lands.

2. Vegetable Crop Pest Control

This subcategory includes commercial applicators using or supervising the use of restricted or general use pesticides in the production of vegetable crops, including but not limited to tomatoes, sweetcorn, asparagus, peas, or beans as well as on grasslands and non-crop agricultural lands.

3. Fruit Crop Pest Control

This subcategory includes commercial applicators using or supervising the use of restricted or general use pesticides in the production of small fruits or tree fruits and nuts, as well as on grasslands and non-crop agricultural lands.

(b) Animal-Livestock Pest Control

This category includes commercial applicators using or supervising the use of restricted or general use pesticides on animals, including without limiting the foregoing, beef cattle, dairy cattle, swine, sheep, horses, goats, poultry, and livestock and to places on or in which animals are confined.

1. Doctors of Veterinary Medicine

Doctors of veterinary medicine engaged in the business of applying pesticides for hire, publicly holding themselves out as pesticide applicators, or engaged in large scale use of pesticides are included in this category.

2. Forest Pest Control

This category includes commercial applicators using or supervising the use of restricted or general use pesticides in forests, forest nurseries and forest seed producing areas.

3. Ornamental and Turf Pest Control

This category includes commercial applicators using or supervising the use of restricted or general use pesticides to control pests in the maintenance and production of ornamental trees, shrubs, flowers, and turf.

4. Seed Treatment Pest Control

This category includes commercial applicators using or supervising the use of restricted or general use pesticides on seeds.

5. Aquatic Pest Control

This category includes commercial applicators using or supervising the use of restricted or general use pesticides purposefully applied to standing or running water, excluding applicators engaged in public health programs for the management and control of pests having medical and public health importance.

6. Right-of-Way Pest Control

This category includes commercial applicators using or supervising the use of restricted or general use pesticides in the maintenance of public roads, electric powerlines, pipelines, railway right-of-way or other similar areas.

7. Industrial, Institutional, Structural, and Health Related Pest Control

(This category is under the jurisdiction of the Illinois Department of Public Health, Chapter 111½, paragraph 2202 et. seq., Illinois Revised Statutes.)

8. Mosquito Control

This category includes commercial applicators using or supervising the use of restricted or general use pesticides for the prevention and control of mosquitoes in, on, or around structures such as schools and hospitals, industrial establishments, and any other structures and adjacent areas, including ditches, canals, low wet areas, and stagnant pools, to prevent the spread of mosquito borne diseases and for control of nuisance level populations of pest mosquitoes. The examination and training of commercial applicators and operators for this category is developed by the Department of Public Health. The examination and certification of applicants is administered by the Department of Agriculture.

9. Regulatory Pest Control

This category includes state, federal or other government employees who use or supervise the use of restricted or general use pesticides in the control of regulated pests.

10. Demonstration and Research Pest Control

This category includes: (1) individuals who demonstrate to the public the proper use and techniques of application of restricted use or general use pesticides or supervise such demonstration, and (2) persons conducting field research with pesticides, and in doing so, use or supervise the use of restricted or general use pesticides.

Included in the first group are such persons as extension specialists and county agents, commercial representatives demonstrating pesticide products and those individuals demonstrating methods used in public programs.

The second group includes: state, federal, commercial and other persons conducting field research on or utilizing restricted use pesticides.

11. Grain Facility Pest Control

This category includes certified applicants using or supervising the use of restricted or general use pesticides for the prevention and control of pests in, on, or around grain elevators or similar grain holding facilities which are not included under the classification of Food Manufacturing, Food Processing, and Food Storage Facility Pest Control (subcategory E of category 7, Industrial, Institutional, Structural, and Health Related Pest Control administered by the Illinois Department of Public Health).

Regulation 6.2. Those persons falling under the definition of private pesticide applicator and agricultural commodities may make application to the Department to become certified as a private pesticide applicator.

Regulation 6.3. Commercial applicators and commercial operators will be deemed qualified to apply pesticides on satisfactory completion of a closed book, supervised written exam covering the following general standards for all categories of certified commercial applicators and commercial operators and the appropriate federal commercial applicator standards of competency given in 40 CFR 171.4 and 171.6.

(i) Label and Labeling Comprehension

- (a) The general format and terminology of pesticide labels and labeling:
- (b) The understanding of instructions, warnings, terms, symbols, and other information commonly appearing on pesticide labels,
- (c) Classification of the product, general or restricted; and
- (d) Necessity for use consistent with label

(ii) Safety - Factors including:

- (a) Pesticide toxicity and hazard to man and common exposure routes;
- (b) Common types and causes of pesticide accidents;
- (c) Precautions necessary to guard against injury to applicators and other individuals in or near treated areas;
- (d) Need for and use of protective clothing and equipment;
- (e) Symptoms of pesticide poisoning;
- (f) First aid and other procedures to be followed in case of a pesticide accident; and

(g) Proper identification, storage, transport, handling, mixing procedures and disposal methods for pesticides and used pesticide containers, including precautions to be taken to prevent children from having access to pesticides and pesticide containers.

(iii) Environment - The potential environmental consequences of the use and misuse of pesticides as may be influenced by such factors as:

(a) Weather and other climatic conditions;

(b) Types of terrain, soil or other substrate;

(c) Presence of fish, wildlife and other non-target organisms; and

(d) Drainage patterns.

(iv) Pests - Factors such as:

(a) Common features of pest organisms and characteristics of damage needed for pest recognition:

(b) Recognition of relevant pests; and

(c) Pest development and biology as it may be relevant to problem identification and control.

(v) Pesticides - Factors such as:

(a) Types of pesticides;

(b) Types of formulations;

(c) Compatability, synergism, persistence and animal and plant toxicity of the formulations;

(d) Hazards and residues associated with use;

(e) Factors which influence effectiveness or lead to such problems as resistance to pesticides; and

(f) Dilution procedures.

(vi) Equipment - Factors including:

(a) Types of equipment and advantages and limitations of each type; and

(b) Uses, maintenance and calibration.

(vii) Application Techniques - Factors including:

(a) Methods of procedure used to apply various formulations of pesticides, solutions, and gases, together with a knowledge of which technique of application to use in a given situation.

(b) Relationship of discharge and placement of pesticides to proper use, unnecessary use, and misuse; and

(c) Prevention of drift and pesticide loss into the environment.

(viii) Laws and Regulations - applicable state and federal laws and regulations.

Regulation 6.4. All properly certified commercial applicators must directly supervise the use and application of non-certified persons (operators) using or applying restricted use pesticides. Ultimate liability for misuse of pesticides by persons under the supervision of an applicator rests with the applicator.

Regulation 6.5. Public applicators and commercial applicators not for hire, upon satisfactory completion of the written tests, will be issued appropriate certification. These applicator categories do not require fees or performance bond.

Regulation 6.6. Public operators upon satisfactory completion of the written test will be issued appropriate license. This operator category does not require a fee.

Regulation 6.7. A private applicator shall be certified as qualified if such person attends an approved training session conducted by the Illinois Cooperative Extension Service and satisfactorily completes an application for certification as a private pesticide applicator or completes an open book, written exam covering the following general standards for private applicators.

1. Recognize common pests to be controlled and damage caused by them.

2. Read and understand the label and labeling information - including the common name of pesticide to be applied; pests(s) to be controlled; timing and methods of application; safety precautions; any pre-harvest or re-entry restrictions; and any specific disposal procedures.

3. Apply pesticides in accordance with label instruction and warnings, including the ability to prepare the proper concentration of pesticide to be used under particular circumstances taking into account such factors as area to be covered, speed at which application equipment will be driven, and the quantity dispersed in a given period of operation.

4. Recognize local environmental situations that must be considered during application to avoid contamination.

5. Recognize poisoning symptoms and procedures to follow in case of a pesticide accident.

6. Understand that the ultimate responsibility for damages due to mis-application of pesticides by a certified applicator or a non-certified applicator under the supervision of a certified applicator shall remain with the supervising certified applicator.

Regulation 6.8. A commercial applicator for hire must meet the requirements of the Custom Pesticide Applicator Law.

Regulation 6.9. A commercial operator for hire must meet the requirements of the Custom Pesticide Applicator Law.

Regulation 6.10. A public pesticide applicator certification or public pesticide operator license is not valid outside of the applicator's or operator's official duties. Such individuals must be additionally certified or licensed for hire or not for hire as appropriate.

Regulation 6.11. In order to maintain current, valid, certification, commercial applicators will be required to be retested at five year intervals and private applicators will be required to attend an approved training session or successfully complete an open book exam at five year intervals.

Regulation 6.12. The Department will issue appropriate credentials to the applicant on satisfactory completion of all requirements for a commercial or public or private applicator certification or commercial or public operator license.

ARTICLE VII: Training

Regulation 7.1. Commercial applicators and commercial operators will not be required to attend training sessions.

Regulation 7.2. Private applicators may attain requirements for certification by attending a training session conducted by the Illinois Cooperative Extension Service or by successful completion of a written, open book, exam.

Regulation 7.3. Training sessions for private applicators will be of a minimum 2-4 hours duration and will cover all general standards for private applicator certification.

Regulation 7.4. Applicants for private applicator certification will be required to complete a training evaluation form consisting of multiple choice questions.

Regulation 7.5. Multiple choice questions will be answered before and after the training session.

Regulation 7.6. Certification will be granted or denied by the Department after evaluation of before and after session question answers.

Regulation 7.7. Applicant attendance at an approved training session will be attested to by applicant signature and the signature of a representative of the Department on the application for certification as a private applicator.

ARTICLE VIII: Record Keeping

Regulation 8.1. Records on restricted pesticide usage will be kept by commercial applicators and will include chemical used, amount of chemical concentration per unit treated (e.g., acre, bushel, cubic area and other applicable measure), date of application, location of application, use, and shall be retained for a minimum of two years.

Regulation 8.2. Dealers will be required to record all sales of restricted use pesticides, and said records will be retained for a minimum of two years.

Regulation 8.3. Records kept by commercial applicators and dealers will be surrendered for inspection by an authorized agent of the certifying agency.

Regulation 8.4. The dealer will record on the retail sales document the number appearing on the valid current license or certificate.

ARTICLE IX: Enforcement

Regulation 9.1. The Department shall engage in activities to insure the correct and lawful use, application, and disposal of pesticides.

Regulation 9.2. Enforcement activities will include sampling of pesticides at producer, distributor, and retail establishments.

Regulation 9.3. Samples obtained will be tested by the Department for compliance with the Economic Poison Law and the Pesticide Control Law.

Regulation 9.4. Department field personnel may investigate all instances of pesticide misuse or adulteration at places of pesticide production, sale, or use.

Regulation 9.5. For the purpose of carrying out the provision of the Act, the Director, or his representative after showing proper identification and stating the purpose of the visit, may enter upon any public or private premise at reasonable times for the purpose of inspecting any aircraft, ground equipment, or inspecting or sampling materials subject to the Act, or observing methods and results of applications of pesticides.

ARTICLE X: Violation

Regulation 10.1. A commercial applicator, commercial operator or private applicator may be found in violation of the Act if such person:

(a) Has engaged in fraudulent business practices.

(b) Applied pesticides under expired certification or license.

(c) Has applied pesticides in a faulty, careless, or negligent manner.

(d) Has caused the poisoning, ruining, spoiling, or making uninhabitable for men or animals any piece of land or body of water by use, application, or disposal of pesticides in a faulty, careless, illegal, or negligent manner.

(e) Has made material mis-statement in the application for original certification or license under the Act.

(f) Has willfully disregarded or violated the Act or any regulation, rule, or provision pursuant thereto.

(g) Has willfully aided or abetted another in the violation of the Act or any regulation or rule pursuant thereto.

(h) Has allowed a certification or license under the Act to be used by a non-certified or unlicensed person.

(i) Has been convicted of any crime, an essential element of which is mis-statement, fraud, dishonesty, conviction in this or another state of any crime which is a felony under the laws of this state or conviction of a felony in a federal court; if the Department determines, after investigation that said conviction impairs the ability to demonstrate competence.

(j) Has misrepresented themselves as possessing the necessary qualifications to apply pesticides for the control of pests.

(k) Uses or supervises the use of any registered pesticide in a manner inconsistent with its labeling approved by U.S. Environmental Protection Agency or Illinois State Registration for that pesticide.

(l) Has falsified any records pursuant to Article VIII, Regulation 8.1.

Regulation 10.2. No person may purchase, use, or supervise the use of any restricted use pesticide unless certified or licensed in accordance with the Pesticide Control Act or Rules and Regulations promulgated hereunder. Those persons who purchase, use, or supervise the use of restricted use pesticides in structural pest control must be certified under the Structural Pest Control Act except where excluded by law. Also, it is unlawful that a person may provide a restricted use pesticide to other than a certified applicator or a person under the supervision of a certified applicator.

ARTICLE XI: Suspension and Revocation

Regulation 11.1. The Director, after a hearing before him or his authorized representative, may deny, suspend, revoke, or modify any certificate or license for violation of the Pest Control Act or any state or federal law relating to pesticides and these Rules and Regulations.

Regulation 11.2. No hearing on alleged violations of the Act shall be held until written complaint is filed with the Director or his representative stating the facts constituting the grounds for denial, revocation, or modification of the certification or license.

Regulation 11.3. If upon preliminary investigation, the Director or his representative, finds there are reasonable grounds to substantiate the complaint, the Director or his representative shall set a hearing date at a location determined by the Department. Notice shall be given to the certified or licensed person of the time and place set for the hearing and charges against the certified or licensed person not less than ten days nor more than fifteen days before the hearing by personal delivery, registered or certified mail.

Regulation 11.4. The Director or his representative shall conduct a hearing on the charges. The certified or licensed person may appear and defend, and may be represented by counsel. Full opportunity shall be afforded for the hearing of all evidence for and against the charges. After the hearing the Director or his representative shall enter an order dismissing the complaint or denying, revoking, or modifying the license, if supported by a preponderance of the evidence. A copy of the Director's or representative's order dismissing the complaint or denying, revoking, or modifying the license or certification shall be immediately sent to the person by registered or certified mail.

Regulation 11.5. The decision of the Director or his representative shall be final on all issues of fact and final in all aspects unless appeal is perfected as provided in the Act.

ARTICLE XII: Penalties

Regulation 12.1. Any person who violates any provision of the Act or any rule or regulation promulgated thereunder shall be subject to the penalties prescribed in the Economic Poison Law, the Pesticide Control Law, or the Custom or Public Application of Pesticides Act and such persons may suffer revocation or suspension of license and/or certification.

ARTICLE XIII: Grain Facility Pest Control

Regulation 13.1. Users of restricted use pesticides, in, on, or around private (commercial) grain handling facilities owned by him or his employer or leased by him or his employer will be considered commercial applicators not-for-hire.

Regulation 13.2. Users of restricted use pesticides in, on, or around grain handling facilities owned or operated by a state, federal or other public agency will be considered public applicators or public operators.

Regulation 13.3. Structural pest control technicians holding a valid certification issued by the Department of Public Health shall not be required to obtain a pesticide applicator's license for grain handling facilities from the Department of Agriculture for the purpose of receiving, storing, handling, shipping or processing grain.

Regulation 13.4. Any structural pest control technicians certified by the Department of Public Health may become certified as a pesticide applicator for grain handling facilities under the jurisdiction of the Department of Agriculture upon submission of application and an affidavit from the Department of Public Health that such person has successfully completed the examinations administered by the Department of Public Health for sub-category "D" and sub-category "E". Structural pest control technicians that are granted a license by the Department of Agriculture shall comply with the regulations specified herein.

Regulation 13.5. Grain handling facility pest control applicators or operators are not allowed to apply pesticides for hire, or to land, or a facility not owned or leased by him or his employer.

Regulation 13.6. Grain handling facility pest control applicators will be considered qualified if they meet all other requirements of commercial applicators not-for-hire or public applicators and pass a written, closed book, examination designed to address the specific pest and pesticide problems that will be found in, on, or around a grain handling facility.

Regulation 13.7. The examination will be compiled by an advisory board comprised of members of the industry, Department of Agriculture and the Department of Public Health. Applicators and operators may attend a series of training sessions presented by the feed and grain industry at various locations throughout the state.

Regulation 13.8. If restricted pesticides are to be used each private grain handling facility must have at least one certified applicator to conduct or supervise pesticide application at each site.

Regulation 13.9. If restricted pesticides are to be used public agencies which have grain handling facilities will be required to have at least one certified applicator to conduct or supervise pesticide application at each site.

Regulation 13.10. If public agencies employ operators at grain handling facilities, the operator must pass a closed book, written examination and meet all other requirements of a public operator before applying pesticides.

Regulation 13.11. Commercial structural pest control technicians must be licensed by the Department of Public Health under the Structural Pest Control Act before being allowed to apply pesticides for hire to private or public grain handling facilities.

LEGISLATIVE POTPOURRI

David A. Gentry

It has been said that recently more things have been going on in the area of pesticides in Washington, D.C., than in the farmers' fields. Trying to keep everyone informed on the activity of the regulatory branches of government would be a full-time job, so this paper can only summarize the more important aspects of pesticide laws and regulations.

Illinois State Plan - Pesticide Dealer Obligations

Anyone selling restricted-use pesticides in the state of Illinois must meet four basic requirements. (1) It is illegal to sell a restricted-use pesticide to a non-certified applicator. Therefore, the dealer must check the purchaser's certification card for his number and the expiration date. (2) On every sales receipt for restricted-use pesticides, the purchaser's certification number must be shown. This is your proof that you sold the pesticides to a certified applicator. (3) All records of the sale of restricted-use pesticides must be kept at least two years. (4) Those records must be surrendered to a representative of the Illinois Department of Agriculture or Illinois Department of Public Health upon request after he has shown proper identification. There are penalties for failure to meet these requirements.

Restricted-Use Pesticides

The initial list of restricted-use pesticides was published for the first time on September 1, 1977. A period for public comment lasted until October 24, 1977. At press time the final list had not yet been published, but it is expected to appear in mid-December. Table 1 is the initial list of restricted-use pesticides. A second group of pesticides is now being considered for restricted-use classification. As pesticides are classified, notices will appear in farming magazines and newspaper columns.

Special Local Needs - Section 24c

Section 24c of the Federal Environmental Pesticide Control Act (FEPCA) allows states the right to register pesticides for special local needs. With permission, growers within a state may legally use a pesticide on their crop if no federal pesticide label exists. Anyone may request the Illinois Department of Agriculture (IDA) for state registration of a pesticide. If the pesticide is to be used on a food or a feed crop, a tolerance must be established before the registration can be approved. If the IDA approves the requested registration, the department forwards the registration to the U.S. Environmental Protection Agency for acceptance. At present Illinois has four approved state registrations:

Amiben on pumpkins
Lannate on horseradish
Sevin for true armyworm on corn
Red Squill for rats in urban areas

Inquiries about state registrations for special local needs should be sent to Juett Hogancamp, Illinois Department of Agriculture, Emmerson Building, State Fairgrounds, Springfield, Illinois 62706.

Table 1. Restricted Use Pesticides, September 1, 1977

Common Name	Trade Name	Restriction
acrolein	Aqualin	all uses
acrylonitrile	Acri-tet	all uses
aldicarb	Temik	all uses
allyl alcohol	....	all uses
aluminum phosphide	Phostoxin	all uses
azinphosmethyl	Guthion	most uses
calcium cyanide	Cyanogas	all uses
demeton	Systox	all uses
endrin	....	all uses
ethyl parathion	....	all uses
fluoroacetamide	1081	all uses
hydrocyanic acid	....	all uses
methomyl	Lannate, Nudrin	some uses
methyl bromide	....	most uses
methyl parathion	....	all uses
mevinphos	Phosdrin	all uses
paraquat	....	most uses
picloram	Tordon	most uses
sodium cyanide	....	all uses
sodium fluoroacetate	1080	all uses
strychnine	....	most uses
sulfotepp	Bladafume	all uses
tepp	....	most uses

IR-4 Program

A cooperative agreement between state and federal agencies exists for requesting federal registrations for pesticides from the USEPA. The IR-4 program allows state and federal agencies to collect the data necessary for registration and submit it to the EPA. This program opens another avenue for pesticides to be registered. In Illinois Dr. Fred Slife is the IR-4 project leader.

Pesticide Enforcement Policy Statements (PEPS)

The USEPA has issued a series of policy statements concerning the enforcement of federal pesticide laws. Of prime concern to agriculturists are the four PEPS summarized below.

PEPS 1: Use of registered pesticides at less-than-label dosage rates. Technically, the only legal dosage rates are those contained on the label. In certain situations, however, less-than-label rates are acceptable. The following conditions must be met before a less-than-label rate is applied: (1) The recommendation for the rate being used is put in writing by a "knowledgeable expert." (2) The rate is expected to be effective and beneficial to man and wildlife. (3) The application follows all other label precautions and directions. (4) The application is not repeated so often as to result in a total higher dosage than the label permits.

PEPS 4: Preventive pest control treatments in the absence of target pests. A pesticide may be applied as a preventive treatment if the following conditions are met: (1) The label does not prohibit preventive treatment. (2) The target pest is expected to infest the area. (3) The pesticide is effective against the target pest and is not harmful to man or to the environment.

PEPS 5: Use of a registered pesticide for the control of pests not named on the label in agricultural and nonstructural pest control. A pesticide may be used on a pest not named on the label providing that the following conditions are met: (1) The occurrence of the unnamed pest is improbable or infrequent. (2) The pesticide is registered for use on the commodity or site to be treated. (3) A "knowledgeable expert" must approve the treatment in writing. (4) The recommendation must be submitted to the state lead agency in writing. (5) No other registered pesticide is available. (6) The user must comply with all other directions, warnings, and precautions. (7) The selected pesticide is not suspended or canceled or the subject of a notice to suspend or cancel. (8) The pesticide is expected to be effective.

PEPS 7: Aerial application of registered pesticides. PEPS 7 is the most recent statement from Washington. An in-depth report on the PEPS is presented elsewhere in this manual.

In several PEPS the term "knowledgeable expert" is used. The USEPA has guidelines to determine if a person qualifies as a knowledgeable expert. The lead agency (in Illinois it is the Department of Agriculture) is responsible for approving the credentials of a knowledgeable expert and for accepting his recommendations. Any questions pertaining to the qualifications of the knowledgeable expert should be directed to the IDA.

Rebuttable Presumption Against Registration (RPAR)

As part of the re-registration of pesticides mandated by Congress in 1972, the USEPA has presumed not to register some pesticides, subject to rebuttal by interested parties, such as growers and manufacturers. This program, called Rebuttable Presumption Against Registration (RPAR), is designed to give an in-depth risk/benefit analysis of certain pesticides selected by the EPA. An RPAR notice is triggered by immediate poisoning hazards to man and environment, long-term health problems, or lack of first aid treatments. In cooperation with the EPA, the U.S. Department of Agriculture through the Extension Service and State Experiment Stations is assisting in the collection of data for the risk/benefit analysis. After the analysis is completed, the EPA will either recommend the pesticide for registration or publish a notice of intent to cancel the use of the pesticide.

A proposed list of fifty pesticides that may have RPAR's issued has been published by the EPA and is presented in Table 2. At present fifteen RPAR's have been issued and are under review (Table 3). No final judgments have been made by the EPA.

Table 2. Proposed RPAR Pesticides, November 1, 1977

Name	Use
AMA	herbicide
ammonium arsenite	wood preservative
arsenic acid	herbicide
arsenic pentoxide	wood preservative
arsenic trioxide	rodenticide
benomyl (Benlate)	fungicide
cacodylic acid and sodium salt	herbicide
cadmium	fungicide
calcium acid methanearsonate	herbicide
calcium arsenate	insecticide
carbaryl (Sevin)	insecticide
carbon tetrachloride	fumigant-grain
coal tar	wood preservative
copper arsenate	insecticide
copper acetoarsenate	insecticide
creosote	wood preservative
DBCP (Fumazone, Nemagon)	fumigant-soil
DEF	herbicide
dichlorvos (DDVP, Vapona)	insecticide
DSMA	herbicide
EPN	insecticide
ethylene dibromide	fumigant-grain
ethylene oxide	fumigant-grain
kepone	insecticide
lead acetate	insecticide
lead arsenate	insecticide
maleic hydrazine	herbicide
merphos	herbicide
MAMA	herbicide
MSMA	herbicide
monuron (Urox)	herbicide
nitrosamine	miscellaneous
n-propylisome	disinfectant
paraquat	herbicide
PCNB	fungicide
pentachlorophenol and salts	wood preservative
perthane	insecticide
phenarsazine chloride	wood preservative
piperonyl butoxide	insecticide
potassium arsenite	miscellaneous
rotenone	insecticide
safrole	disinfectant
sodium arsenate	wood preservative
sodium arsenite	herbicide
sodium pyroarsenate	wood preservative
sulfoxide	disinfectant
10 - 10 oxybisphenoxarsine	fungicide
triallate	herbicide
trichlorfon (Dylox)	insecticide
2,4,5-trichlorophenol and salt	fungicide

Table 3. RPAR Notices Issued, November 1, 1977

Name	Use
(BAAM)	miticide
BHC	insecticide
chlorobenzilate (Acaraben)	miticide
chloroform	....
dialate	herbicide
dimethoate (Cygon)	insecticide
EBDC (maneb, zineb, mancozeb, polyram, amobamn)	fungicide
endrin	insecticide
fluoroacetamide (1081)	rodenticide
lindane	insecticide
pronamide (Kerb)	herbicide
strychnine	rodenticide
strychnine sulfate	rodenticide
sodium fluoroacetate (1080)	rodenticide
toxaphene	insecticide

USING DICAMBA EFFECTIVELY AND CAREFULLY

Richard Behrens

Dicamba (Banvel) is a very active herbicide that controls many annual and perennial broadleaf weeds. This paper describes major dicamba uses in crops, points out advantages in using dicamba, and discusses means of minimizing the drift problem associated with its use.

Preemergence applications of dicamba and alachlor mixtures are more effective for annual broadleaf control than alachlor alone. However, dicamba should not be applied preemergence to sandy soils low in organic matter because of possible corn injury from dicamba leaching if heavy rainfall occurs. Incorporation of dicamba by harrowing or dragging before corn emergence will also increase the possibility of corn injury. Carryover effects on sensitive crops planted the following season have not been a problem with this herbicide.

Dicamba is highly active on both annual and perennial broadleaf weeds when it is applied after the weeds have emerged. In foliar applications, use rates are 50 to 75 percent less than the 1/2 pound per acre used in preemergence applications. With the exception of the mustards, broadleaf weed control with dicamba equals or exceeds the effectiveness of weed control with 2,4-D and is less likely to injure corn. This herbicide is more effective than 2,4-D in controlling Canada thistle, smartweeds, wild buckwheat, and kochia. Postemergence applications of dicamba are valuable for weed control in wheat and oats as well as in corn.

Several broadleaf crops, especially soybeans, are very sensitive to dicamba and may be affected by dicamba drift. Users of dicamba should take special precautions to avoid dicamba drift injury to sensitive crops. When dicamba-sensitive crops are adjacent to or very near the downwind side of the spray area, delay treatment until the wind direction changes. Avoid spray particle drift by reducing the number of small spray drops produced by the sprayer. Lowering spray pressure, increasing nozzle orifice size, and using low drift nozzles or thickening agents are means of minimizing dicamba spray drift. Surfactants should not be added to dicamba because they increase the number of small spray drops. Aerial equipment has a much greater drift potential than ground sprayers and should not be used to apply dicamba. The use of drop nozzles after corn is 8 inches tall is a very effective means of reducing spray drift.

A second kind of drift, vapor drift, may occur when foliar applications of dicamba are used. Dicamba vapors may arise from the leaves of treated plants for several days after the spray application. These vapors may drift onto nearby sensitive crops and cause the same type of abnormal growth or injury caused by spray particle drift. Vapor drift is greatest in hot, dry weather. A very light rainfall, 0.1 inch, is sufficient to stop volatilization and vapor drift. Dicamba volatilization is reduced by low temperatures and is much less if the evaporative surfaces, for example, corn leaves, are small. Therefore, the possibility of vapor drift is minimized when dicamba is applied early in the growing season, that is, from mid-May to early June, when temperatures are normally cooler, corn plants are smaller, and soybeans have not emerged or are small and less susceptible to injury than later in the season. Vapor drift is not a problem when preemergence applications of dicamba are used.

Dicamba is a valuable herbicide for use in corn, wheat, and oats. Recognizing the possibility of spray and vapor drift and knowing how to decrease drift potential should enable applicators to use dicamba effectively and with greater safety.

ELECTROSTATIC SPRAYING: STATE OF THE ART

L.E. Bode, B.J. Butler

Electrostatic spray equipment has been used in industry for years. Many home appliances are painted electrostatically. In this process the spray (and often the equipment lines and containers) are charged to as high as 100,000 volts. As the charged spray particles are attracted toward the grounded appliance panel, they form a very even coat of paint on its flat surface.

Attempting electrostatic spraying outdoors, away from carefully controlled industrial conditions, creates serious problems. First used outdoors in the early 1960's, electrostatic dusters were found to be unreliable. High voltages, typically 15,000 to 20,000 volts, were applied to a sharply pointed electrode, which caused the surrounding air to ionize. Pesticide particles became charged as they were blown past the ionization electrode. The earlier machines were not consistently effective largely because the cloud of dust or spray sometimes lost its electrical charge before it was attracted to the plants. If the initial charge was too high, the cloud of spray would lose part of its charge, and plant leaves acted much like lightning rods, bleeding off some of the electrical charge. Recent research, having identified and solved some of these problems, has produced a new era of electrostatic spraying.

Dr. Ed Law, agricultural engineer with the University of Georgia, has conducted considerable research on electrostatic spraying and believes his newly designed and patented system overcomes the problems of earlier electrostatic machines and will give consistent results. The system developed by Dr. Law uses electrostatic-induction to charge the spray drops and air to transport the charged drops to the plants. The nozzle has a washer-like electrode embedded in the cap of a conventional air-atomizing spray nozzle. The electrode is connected to a miniaturized, built-in power supply that converts output from the ignition battery to 1000 to 2000 volts at less than 10 microamperes. The electrode sets up an intense electrical field within the confines of the specially designed insulated nozzle.

As spray droplets are generated within the nozzle in the presence of the electrode's field, they take on a negative charge by electrostatic induction and are then carried outward toward the plant canopy by a stream of compressed air. The air stream also helps keep the electrode region dry to prevent discharges within the nozzle.

The cloud of negatively charged spray droplets increases plant coverage in two ways. First, since like charges repel, the cloud drives negative ions out of the plant into the ground, leaving the plant with a positive charge. Since opposite charges attract each other, the negative spray particles are drawn onto the plants. At the same time the negatively charged drops in the cloud repel each other so that the cloud expands outward and is drawn to any surface connected to the ground, resulting in greater distribution on the underside of interior leaves and stems than that achieved with uncharged sprays, and a more uniform deposit on the entire plant.

The level of charge necessary on the spray cloud for maximum effectiveness varies for different plants. Pointed or irregular leaf tips, like those on cotton plants, act much like little lightning rods to bleed off or neutralize the electrified pesticide cloud when the charge is too large. Too small a charge, on the other hand, deposits far less than the desired amount of pesticide.

Maintaining an optimally charged spray cloud in the field is accomplished through a calibration and monitoring system. Voltage settings for the correct amounts of electrical charge are maintained under varying conditions by a built-in monitoring electrode in the nozzle. It continuously measures the space-charge density of the pesticide cloud emitted by the nozzle and feeds correction data back to the power supply.

Dr. Law's laboratory and field tests using his sprayer the past two years indicate that effective insect control can be achieved when applying one-half the recommended pesticide rate in 1 gallon of water per acre. Tests have been run on cotton, cabbage, and other crops. Figure 1 summarizes the 1977 results of applying one-half the recommended rate of charged spray on cotton contrasted with conventional spraying at full rates.

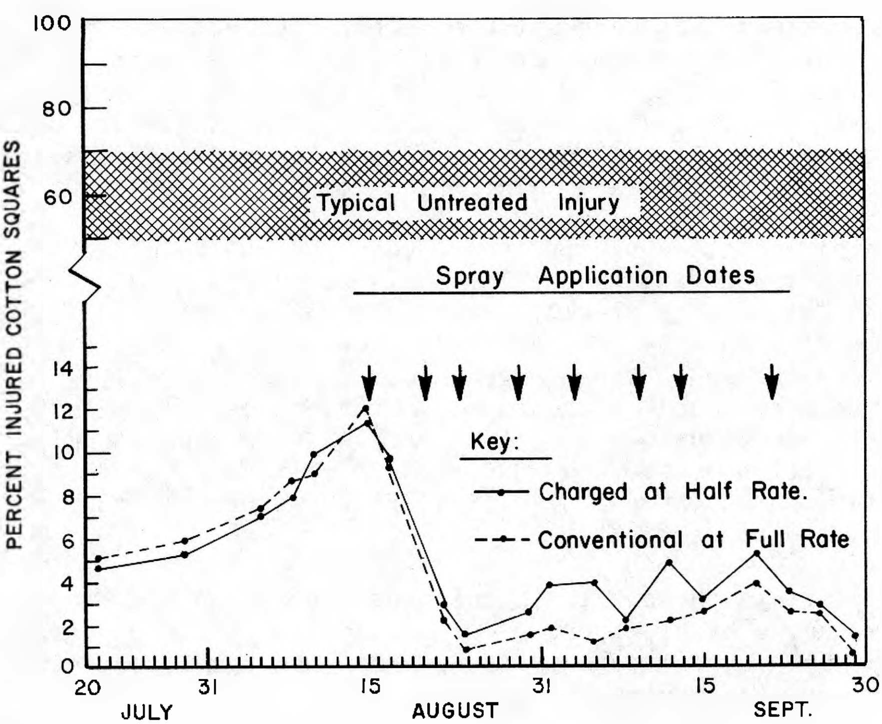

Figure 1. Comparison of cotton square damage from low volume charged spray at one-half rate and conventional spray at full rate.

The electrostatic system shows promise of adaptability to areas other than row crop spraying. Since Dr. Law believes that a system for turf would follow the same technology as that for row crop spraying, he is exploring use of that system using a different spray configuration. He has also made preliminary investigations into orchard spraying and anticipates a full-scale development program.

The electrostatic system would be suitable for home gardening and painting since the electrode can be powered by a transistor radio battery, and it would be safe to use since all high-voltage components are insulated and embedded within the nozzle. Portability of a single-nozzle sprayer would be limited only by a hose leading to a small air compressor similar to those currently in use.

Using electrostatic in aerial spraying would be difficult. Several technical problems caused by the aircraft's inability to complete a ground circuit must be solved before electrostatics can be used in aerial spraying. USDA agricultural engineers Jim Carleton and Fred Bouse at Texas A & M are working on these problems with some success. They are now considering the use of a large antenna to discharge the plane at a distance above the spray cloud.

(This article was written from material supplied by Dr. Ed Law, Agricultural Engineering Department, University of Georgia.)

ILLINOIS PEST MANAGEMENT - PRESENT AND FUTURE

C.D. Bremer

In 1972 an Illinois Pest Management Pilot Program was initiated in Boone County by the Cooperative Extension Service. In subsequent years it has expanded to include cooperators in Shelby, Warren, Hancock, and Iroquois Counties. Initial funding for the Extension program was provided by the Federal Extension Service and the Animal and Plant Health Inspection Service of the USDA. The Illinois program is interdisciplinary, involving weed scientists and entomologists. Plant pathologists provided valuable assistance in training programs for scouts.

From 1973 through 1975 the primary emphasis was placed on developing scouting techniques. Scouting costs were paid from the funds mentioned above. In 1976 and 1977 funding from the Federal Extension Service was reduced, and growers were assessed a fee to cover the cost of hiring the scouts.

Growers, county Extension advisers and Extension specialists in weed science and entomology have worked together to determine the feasibility of pest management scouting programs. A summary of the Extension programs for 1977 is given in Table 1. Note that Boone County is exluded; a program was initiated there in 1977, but was not implemented because of employment problems with scouts.

The pest management program developed by the Extension Service in Illinois has been built around the concept of scouting fields for pests. Scouts check fields weekly from late May through mid-August for potential pest problems (Table 2). The major insect pests monitored are black cutworms, European corn borers, corn leaf aphids, and corn rootworms. In addition, weed population counts and detailed weed surveys are taken during the summer. During the winter individual meetings with growers are scheduled to provide recommendations on insect and weed control for the following year.

Table 1. 1977 Illinois Extension Pest Management Program Summary by County

County	No. of growers	Acres scouted	Av. no. acres per grower	Corn acres	Soybean acres	Alfalfa acres
Shelby	31	2,431	78.4	1.856	575	..
Warren	7	1,276	182.3	1,135	101	40
Hancock	9	2,333	259.2	2,333	...	..
Iroquois	45	2,150	47.8	1,903	247	..
Combined	92	8,190	89.0	7,227	923	40

Table 2. Pest Management Scouting Timetable for Corn

Scouting period	Type of observation
May 20-June 15	Black cutworm, weed infestations, plant populations
June 20-July 5	European corn borer-brood I
July 15-August 1	Corn leaf aphids, weed survey, rootworm beetles
August	Rootworm beetles, yield check

Table 3. Grower Evaluation of Illinois Pest Management Scouting Programs, 1974 through 1977

	1974	1975	1976	1977
Number surveyed and returned	66	43	26	48
		Percent yes		
Has the corn and soybean pest management program helped you do a better job of controlling weeds?	32	30	27	31
insects?	53	37	69	73
As a result of the pest management program, did you do anything different in growing your crop this year?	23	33	46	33[a]
Did you apply any emergency control measures as a result of the scouting program? For weeds?	5	2	12	12
For insects?	3	2	19	25
Did you follow the recommendations made for the growing season?	59	56	69	71
Do you feel that the scout was reliable?	92	98	100	100
Did you study the weekly field survey reports when you received them?	89	93	100	100

[a]Of those surveyed, 69 percent were first-year cooperators and did not have the benefit of previous recommendations.

Data, based on a survey of grower cooperators from 1974 through 1977, indicate that the scouting program is feasible to conduct and that it is acceptable to growers (Table 3). The program was founded to influence grower management practices. Perhaps the most important effects of the program on grower practices have been the use of soil insecticides on the basis of need and the "fine tuning" of herbicide programs.

Pest Management and Agribusiness

One goal of the Extension program is to develop pest management programs that can be adopted and either used directly by growers or offered to farmers as a service by agribusiness firms. A poll of growers participating in the program indicates that private crop protection consulting firms may well have a place in Illinois agriculture. Of those growers polled, many indicated a willingness to pay for insect, disease, and weed scouting. These services can be easily provided in a pest management program by an agribusiness firm (Table 4).

Table 4. Growers Willing to Purchase Crop Protection Services, Polled From 1974 Through 1977

Service	Pct. of growers willing to purchase services			
	1974	1975	1976	1977
Insect scouting	54	44	69	88
Disease scouting	44	33	54	69
Weed control recommendations	27	19	23	31
Soil sampling and recommendations	65	53	15	36

If given a choice, most growers would prefer to use the pest management services offered by pest consulting firms, rather than the services of chemical dealers and manufacturers or grower organizations (Table 5). Purchasing scouting services from private consultants was the most acceptable alternative because consultants are not directly involved in selling agricultural pesticides. Growers involved in the administration of a grower organization prefer pest consulting firms to grower organizations because of the time saved. However, grower organizations and farm chemical dealers do appear to be viable alternatives for delivery.

Table 5. Grower Preferences for Organizations Providing Pest Management Services

Provider of service	Growers' preferences	
	1976	1977
	percent	
Pest consultants	65	56
Grower organizations	54	38
Chemical dealers	12	12
Chemical manufacturers	8	2

The pest management program developed by Extension in Illinois has been adopted in varying degrees by some agribusinesses that now offer their services to growers (Table 6). Scouting services have been provided to growers by some chemical dealers, usually without charge. In 1975 scouting services were offered on a fee basis to growers by private pest consultants. These firms provided the bulk of the scouting in Illinois during 1977. Private pest consultants in Illinois expect to expand their businesses even more in 1978. Firms that offered scouting services in 1977, or are planning to offer a service in 1978, were contacted and asked to estimate their business potential for 1978. If their projections are accurate, there will be over 100,000 acres of crop land scouted in 1978 (Table 7).

Table 6. Pest Management Agribusinesses in Illinois

	1977	1978
	number	
Firms involved	8	9
Full-time employees	10	13
Part-time employees	30	56
Customers	272	?

Table 7. Acres in Illinois Pest Management Scouting Programs, 1973 through 1978

Agency	1973	1974	1975	1976	1977	1978[a]
Extension service	12,605	35,073	31,332	6,097	8,190	8,000
Chemical dealers, soil labs	?	1,000	4,000	4,000	3,300	5,900
Crop protection consultants	....	....	1,000	3,150	41,400	104,100
Total	12,605	36,073	36,332	13,247	52,890	118,000

[a]Projected estimates by existing companies.

Pest management scouting programs are opening new job markets in agribusiness. In 1977 there were ten full-time personnel employed with pest management programs (Table 6). These programs created thirty part-time summer jobs, filled mostly by college students. Programs of this type must necessarily use part-time help. Summer work as a crop scout is excellent experience for most college students in agriculture or related fields, and some students have received extra college credits.

Pest management in Illinois is still in its infancy, but seems to have the potential to grow quickly. A pest mangement scouting program may rapidly become an accepted way for growers to maximize the value of their pesticide dollar. At this time it is difficult to predict how rapidly such programs will be accepted by growers. Some authorities have hypothesized that scouting programs will become as well accepted as soil fertility programs. If present projections by those getting established in the business hold true in 1978, nearly 1 percent of the corn acreage in Illinois may be involved in some form of a pest management scouting program. This estimate does not include the acreage regularly scouted by the farmer. There is no way to estimate this acreage, but each year more growers claim to be scouting their own fields. Most of the readily apparent increase in scouted acreage can be accounted for by those firms whose major interest is pest management.

It is interesting to note that several firms and an Extension pilot county that dropped the scouting program in the past have already reestablished, or are planning to reestablish, a scouting program in 1978. This indicates that growers feel a need for the service, particularly when outbreaks of pests such as corn rootworms occur.

It is unlikely that every acre of crops in Illinois will ever be involved in formal scouting programs - certainly not a program with a fee. Pest management will be an additional tool, which, when used wisely, may enable many growers to take some of the uncertainty out of pest problems. Other tools may be added in the future. For example, in his article "Insect Insurance: Potential Management Tool for Corn Insects" (Bull. Entomol. Soc. Amer. 23 (3): 181-184), F. T. Turpin, research entomologist at Purdue University, has proposed that a form of insect insurance might take some of the uncertainty out of the corn rootworm problem. It is expected, however, that scouting and pest management programs may become important for other reasons. Increased legal restrictions on pesticide use may make it necessary for a qualified person to determine when a pesticide is needed and to recommend its use, although we hope that this procedure will not be necessary for a long time.

Scouting programs can be applied not only to corn, but to other crops as well. Most pest management firms in Illinois now offer equivalent services for soybeans. In the future some firms will offer services for alfalfa and small grains. Pest management also includes weeds, diseases, and nematodes as pests that can be detected and scouted. Special management can often be recommended to minimize their impact. Ten years is a long time to look ahead, but within the next decade pest management will probably be well entrenched in Illinois agriculture.

Pest Management and Extension

The role of extension in pest management will be to try new techniques, help new firms, and educate both the farmer and consultant to the concepts and techniques of pest management. Ongoing education of this type is necessary to ensure that those adopting the scouting program are competent. Until now these efforts have been directed primarily toward insects and weeds. In the future we will include plant diseases and other areas of crop protection. The cooperation of entomology, agronomy, and plant pathology is essential for a well-balanced program that can best serve agriculture.

Extension will be active in presenting in-depth information to pest management personnel, including growers and representatives of agribusiness. At present, one means of presentation is the annual Crop Protection Workshop. Extension will also provide training for the scouts who will monitor the fields. In March, 1977, a scout school trained twenty-two scouts in identification and techniques of scouting for weed, disease, insect, and fertility problems. We also hope to provide training for farmers interested in doing their own scouting.

UPDATE ON SOYBEAN DISEASES

B.J. Jacobsen, M.C. Shurtleff

The 1977 growing season was one of extremes, with unusually dry conditions early in the season and abnormally wet conditions late in the season. Dry soils in the spring resulted in some delayed germination and associated seed rot problems. Wet weather in August, September, and October favored the development of diseases such as Septoria brown spot, purple seed stain, pod and stem blight, stem canker, and anthracnose. The unusually warm weather early in the growing season provided the conditions for early development of the Charcoal rot disease.

Field Diseases and Seed Quality Prospects for 1978

The above-normal rainfall and warm weather during the pod fill stage of soybean development favored the development of Septoria brown spot, which caused premature defoliation, and pod and stem blight, purple seed stain, stem canker, and anthracnose diseases which infect stems, pods, and seeds. Research over the past ten years by J. B. Sinclair of the Department of Plant Pathology has identified the pod and stem blight fungus, *Diaporthe phaseolorum* var. *sojae* (*Phomopsis sojae*), as the single most important factor in soybean seed quality in Illinois.

Initial germinations and seed assays from the Illinois Crop Improvement Association show that the percent of seed infected by fungi (Phomopsis, etc.) is higher and germinations lower in 1977 than in previous years. As of November 1, 1977, 6.8 percent of the seed showed fungal infection and warm germinations averaged 83.6 percent for 306 samples. Seed produced in the northern one-third, central one-third, and southern one-third of Illinois averaged 4.8, 6.4, and 11.8 percent fungal infection, and 86, 85 and 80 percent warm germination, respectively. This compares with statewide warm germination percentages of 79 in 1972, 92 in 1973, 87 in 1974, 86 in 1975, and 88 in 1976. As in past years, fungal seed quality problems are most serious with early maturing varieties for various areas of the state.

At the time of this writing, data on the effects of fungicide sprays on seed quality are not yet available. However, preliminary observations indicate that applications of foliar fungicide did provide some increase both in seed quality (percent seed-borne fungi, germination, and vigor) and yield; see the article in this manual by B. J. Jacobsen and T. M. Sjulin on spraying soybeans.

Soybean producers are strongly urged to plant only high quality seed which germinates greater then 80-85% in a cold germination test, especially since many seed lots will have poor germination and low seedling vigor this year due to fungal infections which could contribute to herbicide injury and other detrimental conditions this spring. Fungicide seed treatments will not increase germination of lots with poor germination due to internal fungal infections, but seed treatment may provide better stands particularly where seed is planted early in cold wet soils. Fungicide seed treatments may also allow a reduced seeding rate. Yield increases from seed treatment are generally not significant although increases of about 1 bu/A is often observed.

Charcoal Rot

Charcoal rot and stem rot was common and caused severe damage, particularly in the southern one-half of Illinois. Since this disease is favored by high soil temperatures, the abnormally high temperatures in June favored early disease development.

Phytophthora Root Rot

New races of *Phytophthora megasperma* var. *sojae*, the causal agent of Phytophthora root rot, were found again in 1977. Varieties such as Amsoy 71, Beeson, Wells, and Culter 71, which are resistant to races 1 and 2, were attacked by new races, particularly in poorly drained fields in east-central Illinois. Chemical controls for this disease are presently being evaluated in several states.

Brown Stem Rot

While this disease was common late in the season, it probably occurred too late to affect yield losses. Since brown stem rot is favored by stress and a cool growing season, it was probably controlled at least in part by the relatively warm temperatures of the 1977 growing season. The only control for this disease is a 3-year crop rotation. Therefore, it is important to rotate heavily infected fields even though little yield loss was observed in 1977.

Soybean Cyst Nematode (SCN)

This nematode was newly identified in Calhoun, Coles, Effingham, Fayette, Iroquois, Jasper, Jersey, Macoupin, Marion, Monroe, and Randolph counties in 1977. Results of the 25 county aerial surveys are not available at the time of this writing.

The new cyst nematode resistant variety, Franklin, was released in 1977. This variety is resistant to race 3 of SCN and is a group IV maturity variety. In trials it has consistently outyielded Custer and has superior agronomic qualities.

Options for control of SCN were narrowed when EPA announced the ban on the use of DBCP. This is the only labeled nematicide which has consistently given good results in University of Illinois trials. Results with Mocap and Nemacur, the other labeled nematicides, have not been as consistent as those with DBCP. Several unlabeled nematicides show promise for SCN control. See the article "The Soybean Cyst Nematode Problem" in this manual for more information on the control and identification of SCN.

WEED CONTROL FOR CORN IN 1978

Ellery L. Knake

This year there will be few changes in the options available to corn growers for their weed control programs.

Preplant

Sutan+ plus atrazine remains a very popular treatment for preplant applications. Either Sutan+ or atrazine may be used alone, but the combination gives broad-spectrum control and allows growers who are concerned about atrazine residue to use reduced rates of atrazine. Also, the fact that the combination is incorporated improves performance if the weather is a little dry. Although there may be some corn injury on rare occasions from Sutan+, the risk is not considered significant or serious. This combination can give better control of velvetleaf than some other treatments. Since Sutan+ must be incorporated soon after application, this chemical is better suited to application by the farmer just ahead of incorporation equipment than it is to custom application. If results are poor, inadequate incorporation methods are often the explanation.

Although atrazine may be used alone either preplant or preemergence, a "full rate" is needed for control of velvetleaf and grass weeds such as giant foxtail, which is still the most widespread weed in Illinois.

Eradicane may not last quite as long during the season as Sutan+, but the Eradicane has generally given better control of specialized weed problems such as Johnson grass, wild cane, and nutsedge. Fortunately, atrazine may now be used in combination with Eradicane.

Princep plus atrazine can be used, especially for relatively early preplant applications, since Princep may lengthen control. However, in relatively dry years there is a little more potential for residue into the next season. Princep can improve control of fall panicum and crabgrass.

Lasso or Lasso plus atrazine may be used preplant within seven days before planting corn. A surface application is generally preferred for control of annual grasses, but incorporation usually improves nutsedge control. Since this combination does not have to be incorporated, it may have some advantage for reduced tillage programs where crop residue prevents good herbicide incorporation.

Either Sutan+, Eradicane, or Lasso may be used alone where grass weeds are the major problem. Early application may be supplemented with an appropriate postemergence treatment for control of broadleaf weeds.

Bladex plus Sutan+ may be used preplant incorporated, but the performance of Bladex is usually considered better when it has been applied to the surface rather than incorporated.

Preemergence

Atrazine remains the backbone of many chemical weed control programs. It performs especially well for control of broadleaf weeds. Although it may be satisfactory for control of grass weeds, the addition of Lasso, propachlor, Bladex, Dual, or possibly Prowl can frequently improve grass control. Such combinations with reduced rates of atrazine can reduce the possibility of effects from atrazine residue the next season. There is some concern about atrazine residue affecting crops the next season. The label clearly states that small grain or small-seeded legumes and grasses should not be planted the next season after atrazine has been used either alone or in combination. So we can have little sympathy for growers who try to get by, but sometimes don't.

With the use of *metribuzin* (Lexone and Sencor) increasing on soybeans, there is increasing concern about the additive effect of atrazine residue and metribuzin on soybeans. It is reasonable to be concerned and to take appropriate precautions, but there appears to be no cause for alarm. No doubt there will be a few brown beans again in 1978. But if rates are selected carefully and applications are accurate and uniform, problems can be minimized.

Using reduced rates of atrazine in combinations for corn and metribuzin in combinations for soybeans helps considerably to lessen the possibility of injury. Although 1977 started out a little dry, the warm, moist conditions later in the season have probably enhanced the degradation of atrazine. Other options are available to those who might be concerned, but some of these options also have disadvantages, such as less corn tolerance.

Bladex can be used alone or in combination with atrazine, Lasso, or Prowl. The Bladex plus Lasso combination has generally performed well. Bladex can be combined with atrazine in various ratios. Increasing the proportion of Bladex can improve control of grasses such as panicum and crabgrass, but may also increase the risk of corn injury under extended cool, wet, adverse conditions. The incidence of injury due to Bladex, particularly in northwestern Illinois, a few years ago is a reminder that Bladex can still injure corn. But there has been little injury the last few years with more favorable weather conditions. Using reduced rates of Bladex in combination helps avoid the problem. The Bladex plus atrazine combination has generally performed well for weed control. There is some interest in a three-way combination of Bladex plus atrazine plus Lasso. However, three-way combinations are still for the most part in the research stage.

Propachlor is available under the trade names Ramrod, Bexton, and Propachlor. Corn has good tolerance to this chemical. Although propachlor does not last as long as Lasso, grass control can be quite good even with low rainfall. Interest by growers in reducing production costs of corn could stimulate more interest in band applications, but it is doubtful that many growers will return to banding. For those who are determined to reduce cash outlay and who have the equipment and time, banding may cut some costs. But growers should also remember the risk with weeds during wet weather when cultivation must be delayed.

Propachlor plus atrazine has been an effective combination, offering both good weed control and good crop tolerance. Unfortunately, the propachlor wettable powder has been irritating to handle. The granular combination AAtram, which contains atrazine and propachlor, has performed relatively well. One manufacturer hopes to increase interest in propachlor by formulating a flowable propachlor that should be easier to handle. This new formulation will probably be registered in the future.

Lasso plus atrazine has been one of the most popular preemergence treatments and has performed well for weed control. Although spraying is the most common means of application, the combination is also available as granules. Corn may occasionally be somewhat affected by Lasso, but this has not been a very significant concern. Lasso is quite versatile in time and method of application and is approved for use in several combinations. If applications are delayed for some reason, the Lasso plus atrazine combination may be used as a delayed preemergence or very early postemergence treatment. Growers interested in low cash outlay can consider banding Lasso and following with a low-cost postemergence herbicide such as 2,4-D.

Banvel plus Lasso has been used the last few years, especially in some areas where growers have been concerned about herbicide residue. Banvel adds broadleaf weed control without risk of residue problems the next season. But fields should not be replanted to soybeans the same season that Banvel is used. There is some risk of injury to corn from this combination, so rates should be selected carefully and applications should be very accurate and uniform. Even with these precautions, injury to corn seedlings may occur in some fields.

Dual is chemically related to Lasso. Experience thus far suggests that Dual may last a little longer during the season and give slightly better control of nutsedge than Lasso, but corn tolerance may be a little less. Dual is registered for preplant as well as preemergence use and may be used in combination with AAtrex.

Prowl is intended primarily for control of grass weeds. Using it in combination with atrazine or Bladex improves broadleaf weed control. For corn, Prowl should be applied only to the soil surface. Incorporation can significantly increase the risk of corn injury. This herbicide probably has more potential for use on soybeans than on corn.

Postemergence

Atrazine and oil may be used early for control of very small grass weeds, but usually preplant or preemergence treatments are preferred. There is a little more flexibility for height of broadleaf weeds. Smartweed is quite sensitive, and atrazine and oil applied postemergence may sometimes give better control of velvetleaf than pre-emergence treatments. The later the application is made, the greater the risk of residue problems the next season. So if fields are treated after June 10, do not plant sensitive crops the next season.

Bladex may be used postemergence through the four-leaf stage of corn but before grass weeds exceed a height of 1 1/2 inches. Do not use petroleum crop oils with Bladex. Under cool, wet stress conditions there is some risk of corn injury from postemergence applications of either atrazine or Bladex.

2,4-D is a low cost treatment for controlling broadleaf weeds in corn. Do not apply 2,4-D to corn from tasseling to dough stage.

Banvel or Banvel plus 2,4-D may be used postemergence in corn for control of broadleaf weeds. However, treatments should be made early before nearby soybeans have emerged or while they are still small. Corn can occasionally be injured by either 2,4-D or Banvel.

Basagran is now registered for postemergence use in corn, but controls only broadleaf weeds, not grasses. However, Basagran has generally given good control of nutsedge in a well-planned program. Seed corn companies concerned about possible injury to seed corn production fields from 2,4-D or Banvel are especially interested in this treatment. For good results be certain to apply Basagran when weeds are quite small. Keep in mind that it does not have as much flexibility in timing as 2,4-D.

Directed postemergence treatments are not popular in Illinois; however, in emergency situations where earlier treatments were not made or were unsuccessful, Lorox and Evik are available. Lorox is applied after corn is at least 15 inches high (free standing) but before weeds are 8 inches tall (preferably not more than 5 inches). Evik is used when corn is more than 12 inches tall and weeds are less than 4 inches tall. Applications should be directed onto the weeds and kept off the corn as much as possible to avoid corn injury.

THIRTY YEARS OF SPRAY SCHOOL

C.T. Hardwick

At first glance, the report of the first Custom Spray Operators Training School seems to indicate things really have not changed since January 12, 1949.

Speakers discussed the repair and maintenance of sprayer pumps and nozzles and rates of application. There was a discussion on the control of flies and one on the legal aspects of custom spraying.

Corn borers pestered farmers 30 years ago, too, as evidenced by the three speakers who addressed that topic. Chemicals were one way to fight insects and then, as now, there was concern about residual toxicity and the effects of chemicals on wildlife and aquatic life.

There have been changes, of course. An obvious change, which indicates the growth of the school, is the size of the spray school book. The first one was 33 pages. Last year's book had 399 pages for speakers' summaries and other information, and another 71 for the pesticide dealers and applicators handbook.

The first spray school included a discussion of a spray schedule for home orchards; most of those are gone, replaced by more corn and soybeans. One speaker talked about several new weed-killing chemicals and suggested that some had commercial possibilities; the resulting boom in herbicides has been a big factor in increased yields.

There was also a discussion on new insecticides. They included benzene hexachloride, DDT, chlordane, and some new chlorinated hydrocarbons. Since then, benzene hexachloride has been voluntarily cancelled by its manufacturer, DDT banned, and chlordane suspended for most general uses. The new chlorinated hydrocarbons for the most part also are gone. For better or worse, these actions came after investigation by something that did not exist in 1949--the U.S. Environmental Protection Agency.

The idea of a spray school occurred to H.B. "Pete" Petty, University of Illinois Extension and Natural History Survey entomologist, because there seemed to be a need for uniform standards that applicators could use in spraying barns for fly control and fields for corn borer control.

Petty talked with custom applicators about the need for an annual custom sprayer training school. Most thought it was a good idea. Petty and W.O. Scott of the University of Illinois Agronomy Department planned for the first Illinois Custom Spray Operators Training School with the help of the University of Illinois Departments of Agricultural Engineering and Horticulture and support from the Office of Agricultural Communications. The Department of Plant Pathology has played an important part in spray school since 1955, when the department was established.

Petty compiled a list of custom spray operators and sent out invitations. About 125 said they planned to attend. The first spray school was scheduled for the Agricultural Engineering Building auditorium, which had 150 seats. By noon, however, participants were standing or sitting anywhere they could find space and the program

Custom Spray School Attendance

	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	Avg.
Ground operators	291	313	349	301	347	377	418	498	566	651	416
Aerial applicators	28	40	30	47	61	46	43	47	54	65	46
Industry	525	553	476	493	507	465	382	462	505	513	488
Seed company	120	103	79	89	87	110	66	102	97	85	94
Farm managers	35	32	29	21	29	18	14	23	19	15	24
Canning company	21	18	22	10	13	13	14	19	8	8	15
Farmers	134	129	109	135	133	79	81	97	111	127	113
State and federal	48	46	41	64	63	55	43	42	46	38	49
Extension advisers	45	40	41	52	63	62	68	79	60	70	58
Faculty and speakers	45	38	37	54	46	67	54	54	65	70	53
Press	12	6	8	14	7	9	8	12	8	19	10
Students	9	41	14	27	22	24	18	21	20	16	21
Miscellaneous	3	0	29	2	0	0	0	0	14	28	8
Total	1,304	1,359	1,264	1,309	1,378	1,325	1,209	1,456	1,573	1,705[a]	1,390

[a]Record attendance.

moved to a larger auditorium in Davenport Hall. Final registration for that first school was 358. Attendance has been growing every year. Last year, 1,075 persons registered, a record.

Petty was chairman of the annual school for 25 years. Stevenson Moore III, another Extension and Natural History Survey entomologist, has served as chairman since 1974.

The spray school doesn't just happen every year. And all the planning will not draw an audience unless potential participants feel there is a need for the program. There is still a need, just as there was 30 years ago.

For one thing, there has been a dramatic increase in pesticide usage. In 1976, 11,438,500 acres were treated with herbicides and 6,738,400 acres with insecticides. Both of those figures have increased since 1972. And that's just cropland, not trees, lawns, buildings, or livestock.

The school offers custom applicators a chance to further their professional education in preparation for licensing and to deal with more complicated equipment and legal requirements. That means the Illinois Custom Spray Operators Training School also will be needed in the future.

Custom spray school is not just for applicators. Those attending represent ground operators, aerial applicators, industry, seed companies, farm management firms, and canning companies. There are also farmers, state and federal officials, Extension advisers, media representatives, and students.

The registration fee is kept as low as possible, and all commercialism is prohibited. Agricultural chemical dealers, salesmen, and technicians make up nearly half of the audience each year, but they come not to sell or deal, only to learn. So does everyone else. And that is the key to the continuing success of spray school.

CHECK LIST OF INSECTICIDES

There are many insecticides listed in Circulars 897 (Commercial Vegetables), 898 (Livestock), 899 (Field Crops), 900 (Homeowner), 1073 (Fruit), and 1076 (Turgrass), containing the current Illinois insecticide recommendations. The following list gives some information about these insecticides; we have also included other insecticides that have label approval but are not in the Illinois recommendations.

The insecticide names are listed at the left in capital letters. Usually these are the common names, but if they are trade names they are marked with an asterisk. Trade names and other identifying names follow the common names. The nam of the basic manufacturer is listed after the trade name.

Toxicity ratings for each insecticide are listed below the name. An acute oral toxicity rating for each insecticide is given. A dermal toxicity rating is also given if known. Acute oral toxicity ratings are usually obtained by feeding white rats, acute dermal ratings by skin absorption tests on rats or rabbits. These figures are expressed as LD50. This means the size of the dose that is lethal to 50 percent of the test animals. LD50 is expressed in terms of milligrams of actual insecticide per kilogram of body weight of the test animal--mg./kg. Chronic oral toxicity (90 days plus) with the no-effect level in the diet is expressed in parts per million. When available, toxicity ratings of insecticides to fish, birds, and honeybees are also given. Those for bees can be interpreted readily as follows: (1) High--kills bees on contact and by residues; bees should be removed from area of application. (2) Moderate--kills bees if applied over them; limited damage with correct dosage, timing, and method of application. (3) Low--can be used around bees with few precautions and a minimum of injury.

To express toxicity in practical terms, the factor .003 times the LD50 value will give the ounces of actual insecticide required to be lethal to one of every two 187-pound men or other warm-blooded animals. As an example, the oral LD50 value for malathion is 1,200 mg./kg.; thus, if a group of men each weighing 187 pounds ate 3.6 ounces (1,200 times .003) of actual malathion per man, half of them would succumb. The dermal-toxicity-LD50 value of malathion is approximately 4,000 mg./kg. or for a 187-pound man, 12 ounces. If you check the list of insecticides, you will find some highly toxic chemicals with LD50 values from 1 to 10 mg./kg. For the average man, fatal doses of these would be in the range of .003 to .03 ounce.

By comparison, the oral LD50 value of aspirin is 1,200 mg./kg. or 3.6 ounces per 187-pound man, the equivalent of malathion. The oral LD50 value of ethyl alcohol is 4,500 mg./kg. If a group of 187-pound men each consumed somewhat more than 1 quart of 80 proof whiskey in 45 minutes they would not only be intoxicated, 50 percent of them might die.

It is important to remember that these toxicity ratings are approximate and pertain to white rats and sometimes rabbits. Such ratings do serve as a guide to compare the toxicity of insecticides as well as an indication of their comparative acute toxicity to other warm-blooded animals and man. Acute toxicity ratings expressed as LD50 are classified as to their relative danger when being used. An acute oral LD50 of 500 mg./kg. or higher is rated as low toxicity, an LD50 rating of 50-500 is moderate, and 50 or less is high.

The chemical group to which the insecticide belongs is given after the toxicity ratings. From this, you can determine which insecticides have similar chemical properties. A brief statement follows the chemical group name, describing in general terms the principal uses for the insecticide. Some of the insecticides are classified as a RESTRICTED USE INSECTICIDE. An applicator who purchases and uses one of these insecticides will need to be certified as a private or commercial applicator. See your county extension adviser for more information, if necessary.

Remember, this is *not* a list of recommended insecticides, nor is it to be used in determining what insecticide to use to control a particular insect. This list is a quick insecticide reference to compare common chemical names with trade names, their toxicity ratings, and general uses.

INSECTICIDES

ABAR*--see leptophos

ABATE*--see biothion

ACARALATE*--see chloropropylate

ACEPHATE — Orthene — Chevron

Acute oral--361 — Fish toxicity--Low
Acute dermal--2,000 — Bird toxicity--Moderate
Organic phosphate--Labeled for use against certain insects on ornamentals and vegetables.

AKTON* — SD 9098 — Shell

Acute oral--146
Acute dermal--177
Organic phosphate--Insecticide for lawn insects.

ALDICARB — UC 21149, Temik — Union Carbide

Acute oral--5-10 (10% G) — Bird toxicity--Moderate
Acute dermal--1,400 (10% G)

Carbamate--Residual, systemic insecticide and miticide for use against mites, and certain insects of ornamentals and cotton. RESTRICTED USE INSECTICIDE.

*Trade name.

ALDRIN Shell

Acute oral--39-60
Acute dermal--98
Chronic oral--0.5

Fish toxicity--Very high
Bee toxicity--High
Bird toxicity--High

Chlorinated hydrocarbon--Manufacture for agricultural use prohibted.

ALFA-TOX* CIBA-Geigy

A combination of methoxychlor and diazinon used as a spray for alfalfa weevil control.

ALLETHRIN Synthetic pyrethrin, Pynamin FMC, Benzol Products

Acute oral--680-1,000
Acute dermal--11,200
Chronic oral--5,000

Bee toxicity--Low

Synthetic derivative--Used in household aerosols and fly sprays as a quick knockdown.

ALTOSID--see methoprene

ALUMINUM PHOSPHIDE Phostoxin Hollywood Termite Company

Fumigant--Used on stored products. Highly toxic when phosphine gas is formed. RESTRICTED USE INSECTICIDE.

ARAMITE* U.S. Rubber

Acute oral--3,900
Chronic oral--500

Fish toxicity--Moderate
Bee toxicity--Low
Bird toxicity--Very low

Sulfonate--Miticide limited to ornamentals and household. No clearance on fruit or vegetables, has carcinogenic properties.

ASPON* Stauffer

Acute oral--1,224

Bird toxicity--Very low

Organic phosphate--For control of chinch bugs and sod webworms in turfgrass.

AZINPHOSMETHYL Guthion Chemagro

Acute oral--11-13
Acute dermal--220
Chronic oral--5

Bee toxicity--High
Bird toxicity--Moderate

Organic phosphate--Used on cotton, forage crops, ornamental crops, and tree fruit to control both insects and mites. RESTRICTED USE INSECTICIDE.

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*Trade name

AZODRIN* SD 9129 Shell

Acute oral--21
Acute dermal--354
Chronic oral--1

Bee toxicity--High
Bird toxicity--High

Organic phosphate--Systemic insecticide for use on cotton and fruit crops upon label approval.

BACILLUS POPILLIAE Doom

Bacterial--Nontoxic microbial insecticide. Applied to soil to infect Japanese beetle grubs with milky disease.

BACILLUS THURINGIENSIS Thuricide, Dipel, Bactur, Others Abbott Lab, Sandoz-Wander, Thompson-Hayward

Bee toxicity--Low

Bacterial--A nontoxic microbial insecticide used to control caterpillars on vegetable crops and ornamentals.

BACTUR*--see Bacillus thuringiensis

BAYGON*--see propoxur

BAYTEX*--see fenthion

BENDIOCARB Ficam, NC 6897 Fisons

Acute oral--179
Acute dermal--1,000

Carbamate--Labeled for use on cockroaches and other household insects.

BENZYL BENZOATE Monsanto

Acute oral--500-5,000
Repellent--A repellent for chiggers, mosquitoes, and ticks on man.

BIDRIN* Shell

Acute oral--22
Acute dermal--225
Chronic oral--1

Bee toxicity--High
Bird toxicity--High

Organic phosphate--Systemic insecticide used for mimosa webworm control on honey locust. Recommended in many states as an injected systemic for elm bark beetle control but to be applied only by people especially trained to do the work.

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*Trade name.

BINAPACRYL | Morocide, Acricid | FMC

Acute oral--161
Acute dermal--1,350

Bee toxicity--Low

Nitrophenol--A miticide for certain fruit crops.

BIOTHION | Abate | American Cyanamid

Acute oral--1,000-3,000
Acute dermal--1,024-1,782
Chronic oral--2

Bird toxicity--Moderate

Organic phosphate--Used as a larvicide for mosquito control.

BUTOXY POLYPROPYLENE GLYCOL | Crag Fly Repellent | Union Carbide

Acute oral--9,100-11,200
Chronic oral--640

Repellent--Used in sprays for cattle against flies.

BUX* | Ortho 5353 | Chevron

Acute oral--87
Acute dermal--400

Bird toxicity--Very low

Carbamate--Used for soil insect control in corn.

CARBARYL | Sevin | Union Carbide

Acute oral--500-850
Acute dermal--4,000+
Chronic oral--200

Fish toxicity--Very low
Bee toxicity--High
Bird toxicity--Very low

Carbamate--A general insecticide registered for control of many pests of field crops, vegetables, fruit, the household, and livestock.

CARBOFURAN | NIA 10242, Furadan | FMC, Chemagro

Acute oral--8-14
Acute dermal-->1,000

Bird toxicity--Moderate

Carbamate--Systemic insecticide for corn and certain vegetable soil insects and use on alfalfa for alfalfa weevil control.

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*Trade name

CARBON DISULFIDE Stauffer

Chronic vapor--20 ppm. (40 hr.)
Acute vapor--200 ppm. (1 hr.) Allied, Diamond Shamrock, Dow, FMC, Frontier, Stauffer

Fumigant--Used on stored products.

CARBON TETRACHLORIDE Allied, Diamond Shamrock, Dow, FMC, Frontier, Stauffer

Acute oral--5,730-9,770
Acute dermal--5,070-8,780
Chronic vapor--10 ppm. (40 hr.)
Acute vapor--300 ppm. (1 hr.)

Fumigant--Used as safener in fumigant mixtures for stored grain insects.

CARBOPHENOTHION Trithion, Garrathion Stauffer

Acute oral--10-30
Acute dermal--27-54
Chronic oral--5

Bee toxicity--Moderate

Organic phosphate--Insecticide with lasting residue with limited use on some fruit and vegetables. It is used chiefly as a miticide.

CHLORDANE Octachlor, Octa-Klor, Belt Velsicol

Acute oral--335-430
Acute dermal--690-840
Chronic oral--25+

Fish toxicity--Very high
Bee toxicity--High
Bird toxicity--Moderate

Chlorinated hydrocarbon--A residual soil insecticide for termites. Manufacture for crop use prohibited.

CHLORDIMEFORM Galecron, Fundal CIBA-Geigy, Nor-Am

Acute oral--162-170
Acute dermal--225
Chronic oral--250

Bird toxicity--Low

Formandidine--Manufacture for agricultural use prohibited.

CHLOROPICRIN Picfume Dow, Morton

Chronic vapor--0.1 ppm. (40 hr.)
Acute vapor--20 ppm. (1 hr.)

Fumigant--Used on stored products in ship holds.

*Trade name.

CHLOROPROPYLATE Acaralate CIBA-Geigy

Acute oral--34,600
Acute dermal--10,200
Chronic oral--40

Bee toxicity--Low

Chlorinated hydrocarbon--Miticide for fruit crops.

CHLORPYRIFOS Dursban, Lorsban Dow

Acute oral--97-276
Acute dermal--2,000

Bird toxicity--Moderate

Organic phosphate--Used as a soil insecticide in corn and for mosquito control. Used for roach control as well as for lawn insects. Labeled for peach, ash, and lilac borer control.

CIODRIN*--see crotoxyphos

CIOVAP*--mixture of crotoxyphos and dichlorvos. Used as a spray on cattle for pasture flies.

CO-RAL*--see coumaphos

COUMAPHOS Co-Ral Chemagro

Acute oral--15-41
Acute dermal--860
Chronic oral--5

Bee toxicity--Moderate
Bird toxicity--Moderate

Organic phosphate--A systemic insecticide for beef cattle and poultry to control grubs, lice, and mites.

COUNTER*--see terbufos

CROTOXYPHOS Ciodrin, SD 4294 Shell

Acute oral--125
Acute dermal--385
Chronic oral--7

Bee toxicity--High

Organic phosphate--Used to control livestock, insects, especially biting flies.

CRUFOMATE Dowco 132, Ruelene Dow

Acute oral--460-635
Acute dermal--2,000-4,000
Chronic oral--10-30

Organic phosphate--A systemic insecticide for controlling grubs and lice on beef cattle.

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*Trade name

CYGON*--see dimethoate

CYTHION*--see malathion

DASANIT*--see fensulfothion

DDD*--see TDE

DDT

Acute oral--113-118	Fish toxicity--Very high
Acute dermal--2,510	Bee toxicity--Moderate
Chronic oral--5	Bird toxicity--Moderate

Chlorinated hydrocarbon--Illegal for sale or use in Illinois except by permit.

DDVP*--see dichlorvos

DEET	Off, Delphene, diethyltoluamide diethyl-meta-toluamide	Hercules

Acute oral--1,950
Acute dermal--10,000

Repellent--Used for control of biting insects and chiggers on man. Applied directly to skin.

DE-FEND*--see dimethoate

DELNAV*--see dioxathion

DEMETON	Systox	Chemagro

Acute oral--2-6	Fish toxicity--Moderate
Acute dermal--8-14	Bee toxicity--Low
Chronic oral--1	Bird toxicity--Moderate

Organic phosphate--A systemic miticide and aphicide for use in greenhouses and orchards, and on certain field and vegetable crops. RESTRICTED USE INSECTICIDE.

DESSIN*	Murphy, Union Carbide

Acute oral--100-155
Acute dermal--1,000

Carbonate--Miticide for fruit crops.

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*Trade name

DIAZINON | Spectracide | CIBA-Geigy

Acute oral--76-108
Acute dermal--455-900
Chronic oral--1

Fish toxicity--High
Bee toxicity--High
Bird toxicity--High

Organic phosphate--A general insecticide; can be used as a residual fly spray in barns and for control of insect pests of turf, vegetables, fruit, and the household.

DIBROM*--see naled

DIBUTYL PHTHALATE | DBP | Allied, Monsanto, Commercial Solvent

Acute oral--5,000-15,000

Bird toxicity--Very low

Repellent--For impregnating clothing to repel chiggers and mites.

DICHLORVOS | DDVP, Vapona | Shell

Acute oral--56-80
Acute dermal--75-107

Fish toxicity--Moderate
Bee toxicity--High
Bird toxicity--Moderate

Organic phosphate--Short-lived residual insecticide for livestock, fly bait, greenhouses, and warehouses. Also impregnated in plastic resin strips.

DICOFOL | Kelthane | Rohm and Haas

Acute oral--1,000-1,100
Acute dermal--1,000-1,230
Chronic oral--20

Fish toxicity--High
Bee toxicity--Low
Bird toxicity--Low

Chlorinated hydrocarbon--Miticide used on vegetables, fruit, and ornamentals.

DIELDRIN | Octalox | Shell

Acute oral--46
Acute dermal--60-90
Chronic oral--0.5

Fish toxicity--Very high
Bee toxicity--High
Bird toxicity--Moderate

Chlorinated hydrocarbon--Manufacture for agricultural use prohibited.

DIMETHOATE | Cygon, De-Fend, Rogor, Roxion | American Cyanamid

Acute oral--215
Acute dermal--400-610
Chronic oral--5

Fish toxicity--Very low
Bee toxicity--High
Bird toxicity--Moderate

Organic phosphate--A systemic insecticide for use on fruit, vegetable, and ornamental crops and as a residual fly spray inside of livestock barns.

*Trade name

DIMETHYL PHTHALATE | DMP | Monsanto, Allied

Acute oral--8,200
Acute dermal--4,000+

Repellent--General purpose mosquito repellent.

DINITRO COMPOUNDS | Elgetol 318, DNOC | Dow, FMC, Chem. Ins. Corp.

Acute oral--5-60
Acute dermal--150-600

Nitrophenol--Used primarily for controlling aphids, mites, and scale insects as dormant fruit spray.

DINOCAP | Karathane | Rohm and Haas

Acute oral--980-1,190
Acute dermal--4,700-9,400

Dinitro--A fungicide used for control of powdery mildew; also acts as a mite suppressant.

DIOXATHION | Delnav, Navadel | Hercules

Acute oral--23-43
Acute dermal--63-235
Chronic oral--4

Bee toxicity--Low
Bird toxicity--Low

Organic phosphate--Miticide and insecticide used as an animal dip and spray.

DIPEL*--see Bacillus thuringiensis

DIPTEREX*--see trichlorfon

DISULFOTON | Di-Syston, dithiodemeton, thiodemeton | Chemagro

Acute oral--2-7
Acute dermal--6-15
Chronic oral--2

Bee toxicity--Moderate
Bird toxicity--Moderate

Organic phosphate--A systemic insecticide to control aphids, leafhoppers, and flea beetles on certain vegetable crops. Also a soil insecticide for corn.

DI-SYSTON*--see disulfoton

DURSBAN*--see chlorpyrifos

DYFONATE*--see fonofos

DYLOX*--see trichlorfon

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*Trade name

ENDOSULFAN | Thiodan, Malix | FMC

Acute oral--18-43
Acute dermal--74-130
Chronic oral--30

Bee toxicity--Moderate
Bird toxicity--Low

Chlorinated hydrocarbon--Used on some vegetable crops to control aphids and peach borer.

ENDRIN | Shell, Velsicol

Acute oral--8-18
Acute dermal--15-18
Chronic oral--1

Fish toxicity--Very high
Bee toxicity--Moderate
Bird toxicity--High

Chlorinated hydrocarbon--Use not recommended in Illinois.

ENTEX*--see fenthion

EPN | DuPont

Acute oral--8-36
Acute dermal--25-230

Bee toxicity--High
Bird toxicity--Moderate

Organic phosphate--Used for insect control on field crops.

ETHION | Nialate | FMC

Acute oral--27-65
Acute dermal--62-245
Chronic oral--3

Bee toxicity--Low
Bird toxicity--Very low

Organic phosphate--Used for onion maggot control, and aphids and mite control in orchards.

ETHOPROP | Mocap | Mobil

Acute oral--62
Acute dermal--26

Bird toxicity--Moderate

Phosphate--Residual chemical for control of soil insects and nematodes.

ETHYLENE DIBROMIDE | American Potash, Dow, FMC, Great Lakes, Michigan Chemical

Acute oral--117-146
Acute dermal--300
Chronic vapor--25 ppm. (40 hr.)
Acute vapor--200 ppm. (1 hr.)

Fumigant--Used on stored products.

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*Trade name

ETHYLENE DICHLORIDE — Diamond Shamrock, Dow, Olin Mathieson

Acute oral--770
Acute dermal--3,890
Chronic vapor--50 ppm. (40 hr.)
Acute vapor--1,000 ppm. (1 hr.)

Fumigant--Used on stored grains.

EUGENOL — Penick

Acute oral--500-5,000

Attractant--Used for attracting fruit flies.

FAMPHUR — Famphos, Warbex — American Cyanamid

Acute oral--35-62
Acute dermal--1,460-5,093
Chronic oral--1

Bird toxicity--High

Organic phosphate--A systemic insecticide used for controlling grubs in cattle.

FENSULFOTHION — Bayer 25141, Dasanit — Chemagro

Acute oral--2-11
Acute dermal--3-30

Bird toxicity--High

Organic phosphate--Insecticide and nematicide for soil insect control in corn and for onion maggot control.

FENTHION — Baytex, Entex, Tiguvon — Chemagro

Acute oral--215-245
Acute dermal--330
Chronic oral--2

Fish toxicity--Low
Bee toxicity--High
Bird toxicity--High

Organic phosphate--Residual fly spray for livestock barns. Used in mosquito control and for household insects.

FICAM*--see bendiocarb

FONOFOS — N2790, Dyfonate — Stauffer

Acute oral--16
Acute dermal--319

Bird toxicity--Moderate

Organic phosphate--Used for soil insect control on corn and vegetable crops.

FUNDAL*--see chlordimeform

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*Trade name

FURADAN*--see carbofuran

GALECRON*--see chlordimeform

GARDONA*--see stirofos

GERANIOL Fritche

Attractant--Used as an attractant in traps for Japanese beetle.

GUTHION*--see azinphosmethyl

GYPLURE USDA

Attractant--Used as an attractant for gypsy moths.

HEPTACHLOR Velsicol

Acute oral--100-162
Acute dermal--195-250
Chronic oral--0.5-5

Fish toxicity--Very high
Bee toxicity--High
Bird toxicity--Moderate

Chlorinated hydrocarbon--Used as a corn soil insecticide. Manufacture for crop use prohibited except for seed treatment.

HYDROCYANIC ACID HCN

Acute oral--4
Chronic vapor--10 ppm. (40 hr.)
Acute vapor--40 ppm. (1 hr.)

Fumigant--Used on stored products, for rodent control and building fumigation.

IMIDAN*--see phosmet

ISOFONPHOS Oftanol, Bay SRA-12869 Chemagro

Acute oral--38
Acute dermal--188
Organic phosphate--Unlabeled corn soil insecticide.

KARATHANE*--see dinocap

KELTHANE*--see dicofol

KORLAN*--see ronnel

LANDRIN* Shell

Acute oral--178
Acute dermal-->2,500

Bird toxicity--Low

Carbamate--Used as a soil insecticide for corn.

*Trade name

LANNATE*--see methomyl

LEAD ARSENATE

Acute oral--1,050 | Bee toxicity--High
Acute dermal--2,400+ | Bird toxicity--Low

Arsenical--Used to control certain chewing insects of fruit and ornamentals.

LETHANE 60* | Rohm and Haas

Acute oral--250-500
Acute dermal--3,000

Thiocyanate--Used in household insecticide sprays.

LETHANE 384*

Acute oral--90
Acute dermal--250-500

Thiocyanate--Used in livestock fly sprays as a quick knockdown agent.

LINDANE | gamma BHC | Hooker

Acute oral--88-91 | Fish toxicity--Very high
Acute dermal--900-1,000 | Bee toxicity--High
Chronic oral--50 | Bird toxicity--Moderate

Chlorinated hydrocarbon--Used to control spittlebugs on certain crops and mite and louse control on certain livestock.

LORSBAN*--see chlorpyrifos

MALATHION | Cythion | American Cyanamid

Acute oral--1,000-1,375 | Fish toxicity--High
Acute dermal--4,444+ | Bee toxicity--High
Chronic oral--100-1,000 | Bird toxicity--Low

Organic phosphate--General use insecticide for control of household insects, certain livestock insects and certain crop insects. Premium grade used for treating grain to be stored.

MESUROL*--see methiocarb

METALDEHYDE

Acute oral--1,000

Attractant--Used in combination with stomach poisons for snail and slug baits.

META-SYSTOX R*--see oxdemetonmethyl

*Trade name

METHIDATHION | Supracide | CIBA-Geigy

Acute oral--25-65
Acute dermal--375-640

Organic phosphate--For alfalfa weevil control.

METHIOCARB | Mesurol | Chemagro

Acute oral--130-135 | Bird toxicity--Low
Acute dermal--200

Carbamate--Prepared as a bait for snail and slug control in nonfood crop areas. Labeled for insect control on peach and cherry. Is a bird repellent.

METHOMIDE | Monitor, Ortho 9006 | Chevron

Acute oral--18-21
Acute dermal--118

Organic phosphate--Labeled for use on cole crops, potatoes, and cotton. Not lettuce.

METHOMYL | 1179, Lannate, Nudrin | DuPont

Acute oral--17-24 | Bird toxicity--Low
Acute dermal--1,500
Chronic oral--100

Carbamate--Used for worm control on cabbage, tomatoes, sweet corn, and field corn and soybeans. RESTRICTED USE INSECTICIDE.

METHOPRENE | Altosid | Zoecon

Acute oral--734,600 | Fish toxicity--Very low
Bird toxicity--Very low

Insect Growth Regulator--Larvicide for flood water mosquitoes and as a feed-through for beef cattle for horn flies.

METHOXYCHLOR | Marlate | DuPont, CIBA-Geigy

Acute oral--5,000 | Fish toxicity--Very high
Acute dermal--6,000+ | Bee toxicity--Low
Chronic oral--100 | Bird toxicity--Very low

Chlorinated hydrocarbon--Used in many homeowner fruit and vegetable spray or dust mixtures; for certain field crop insects, and for Dutch elm disease control.

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*Trade name

METHYL BROMIDE — Bromomethane — American Potash, Dow, Frontier, Great Lakes, Michigan Chemical

Chronic vapor--20 ppm. (40 hr.)
Acute vapor--200 ppm. (1 hr.)

Fumigant--Used on stored products. RESTRICTED USE INSECTICIDE.

METHYL PARATHION — Metacide, Nitrox, Metron — American Potash, Monsanto, Shell, Stauffer

Acute oral--14-24
Acute dermal--67

Fish toxicity--Very low
Bee toxicity--High
Bird toxicity--Moderate

Encapsulated

Acute oral--270-480
Acute dermal--5,400

Organic phosphate--It is closely related to parathion and is used primarily for insect control on cotton. RESTRICTED USE INSECTICIDE.

METHYL TRITHION* — Stauffer

Acute oral--98-120
Acute dermal--190-215

Bee toxicity--High
Bird toxicity--Low

Organic phosphate--It is closely related to trithion or carbophenothion. It is a residual insecticide used in both insect and mite control on certain fruits and vegetables.

MEVINPHOS — Phosdrin — Shell

Acute oral--4-6
Acute dermal--4-5
Chronic oral--0.8

Bee toxicity--High
Bird toxicity--Moderate

Organic phosphate--A short-lived residual insecticide for control of insects on certain field and vegetable crops. RESTRICTED USE INSECTICIDE.

MGK-R11* — MGK

Acute oral--2,500
Acute dermal--2,000+

Repellent--Used in sprays for cattle against flies.

MGK-R326* — MGK

Acute oral--5,230-7,230
Acute dermal--9,400

Repellent--Used in sprays for cattle against flies.

*Trade name

MOCAP*--see ethoprop

MONITOR*--see methomide

MORESTAN* Chemagro

Acute oral--1,100-1,800
Acute dermal--2,000+
Chronic oral--50

Bee toxicity--Low

Organic carbonate--Miticide to be used on apples prior to bloom.

MOROCIDE*--see binapacryl

NALED Dibrom Chevron

Acute oral--250
Acute dermal--800

Fish toxicity--High
Bee toxicity--High
Bird toxicity--Low

Organic phosphate--A short-lived residual insecticide for use in greenhouses and for certain field crops. Also used in fly baits in livestock barns.

NEGUVON*--see trichlorfon

NICOTINE Black Leaf 40, Nicotine Sulfate Center Chemical, Inc.

Acute oral--83
Acute dermal--285

Bee toxicity--Low

Heterocyclic botanical compound--Contact insecticide that is used to control aphids.

NUDRIN*--see methomyl

OFTANOL*--see isofonphos

OMITE Uniroyal

Acute oral--2,200

Bee toxicity--Low

Sulfite--Miticide for use on fruit crops. Not harmful to predatory mites.

ORTHENE*--see acephate

OXYDEMETONMETHYL Meta-Systox R Chemagro

Acute oral--65-75
Acute dermal--250
Chronic oral--10

Bee toxicity--Moderate
Bird toxicity--Moderate

Organic phosphate--A systemic insecticide for controlling aphids, mites, and other plant-sucking insects on vegetable crops.

*Trade name

PARADICHLOROBENZENE PDB, Paracide Dow, Monsanto

Acute oral--1,000+

Fumigant--Used as fumigant to control fabric pests.

PARATHION Alkron, Niran, Stathion, Thiophos American Potash, Monsanto, Shell, Stauffer, Velsicol

Acute oral--4-13
Acute dermal--7-21
Chronic oral--1

Fish toxicity--High
Bee toxicity--High
Bird toxicity--Moderate

Organic phosphate--A highly toxic insecticide to control a wide range of insects and mites on vegetable, fruit, and field crops. RESTRICTED USE INSECTICIDE.

PENTAC* HRS-16 Hooker

Acute oral--3,160
Acute dermal--3,160+

Bee toxicity--Low

Chlorinated hydrocarbon--Residual miticide used on greenhouse floral crops and nursery stock.

PERTHANE* Rohm and Haas

Acute oral--4,000+
Chronic oral--500

Fish toxicity--Very high
Bee toxicity--Moderate
Bird toxicity--Very low

Chlorinated hydrocarbon--Used in formulating household insecticides.

PHORATE Thimet American Cyanamid

Acute oral--1-3
Acute dermal--3-6

Bee toxicity--Moderate
Bird toxicity--Moderate

Organic phosphate--A systemic insecticide for use on certain vegetable and field crops, and as a soil insecticide for corn.

PHOSALONE Zolone Rhodia

Acute oral--120

Organic phosphate--Used as a miticide and insecticide on fruit trees.

PHOSDRIN*--see mevinphos

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*Trade name

PHOSMET — R-1504, Prolate, Imidan — Stauffer

Acute oral--147-216
Acute dermal--3,160

Bird toxicity--Low

Organic phosphate--Insecticide for fruit and ornamental insect control, alfalfa insects, and cattle grubs.

PHOSPHAMIDON — Dimecron — Chevron

Acute oral--24
Acute dermal--107-143

Fish toxicity--Very low
Bee toxicity--High
Bird toxicity--High

Organic phosphate--A systemic insecticide for use on certain fruit and vegetable crops.

PHOSTOXIN*--see aluminum phosphide

PHOSVEL*--see leptophos

PIPERONYL BUTOXIDE — Butocide — FMC

Acute oral--7,500+
Acute dermal--1,880
Chronic oral--1,000

Synergist--Commonly used with pyrethrum.

PLICTRAN — Dow

Acute oral--1,675

Tin--Miticide for use on fruit and greenhouse crops. Not harmful to predatory mites.

PROLATE--see Imidan

PROPOXUR — Baygon — Chemagro

Acute oral--95-104
Acute dermal--1,000+
Chronic oral--800

Bird toxicity--Low

Carbamate--For use against mosquitoes, household insects, and certain lawn insects.

PROXOL*--see trichlorfon

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*Trade name

PYRETHRUM pyrethrin I and II FMC, Penick, MGK

Acute oral--820-1,870
Acute dermal--1,880+
Chronic oral--1,000

Fish toxicity--High
Bee toxicity--Low
Bird toxicity--Very low

Botanical--Used as a fly control insecticide in household and livestock sprays.

RABON*--see stirofos

RAVAP*--mixture of dichlorvos and stirofos. Used as a residual wall spray for flies in livestock barns.

RESMETHRIN SBP-1382 Penick

Acute oral--3,500
Acute dermal--3,040

Bird toxicity--Very low

Synthetic pyrethrin--Used for flying and nuisance insects and whitefly control.

RONNEL Korlan, Trolene, Viozene Dow

Acute oral--1,250-2,630
Acute dermal--5,000+
Chronic oral--10

Organic phosphate--Used in baits and sprays for fly control in livestock barns.

ROTENONE derris, cube FMC, Penick

Acute oral--50-75
Acute dermal--940+
Chronic oral--25

Fish toxicity--Very high
Bee toxicity--Low
Bird toxicity--Low

Botanical--A contact poison used to control certain home garden insects and cattle grubs.

RUELENE*--see crufomate

SEVIN*--see carbaryl

SPECTRACIDE*--see diazinon

STIROFOS Rabon, Gardona Shell

Acute oral--4,000-5,000
Acute dermal--5,000+

Bird toxicity--Very low

Organic phosphate--For control of livestock flies and external parasites of livestock; also, for worms attacking sweet corn.

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*Trade name

SULFOXIDE | Sulfox-Cide | Penick

Acute oral--2,000
Acute dermal--9,000+
Chronic oral--2,000

Synergist--Commonly used with phrethrum.

SUPRACIDE*--see methidathion

SYSTOX*--see demeton

TDE | DDD, Rhothane | Allied, Rohm and Haas

Acute oral--4,000+ | Fish toxicity--Very high
Acute dermal--4,000+ | Bee toxicity--Moderate
Chronic oral--100 | Bird toxicity--Moderate

Chlorinated hydrocarbon--Illegal for sale or use in Illinois.

TEDION*--see tetradifon

TEMIK*--see aldicarb

TERBUFOS | Counter | American Cyanamid

Acute oral--4-9 | Bird toxicity--High
Acute dermal--25 | Fish toxicity--High

Organic phosphate--A soil insecticide for the control of corn soil insects.

TETRADIFON | Tedion | FMC, Phillips

Acute oral--14,700+ | Bee toxicity--Low
Acute dermal--10,000+ | Bird toxicity--Very low

Sulfonate--A miticide for fruit crops.

THANITE* | | Hercules

Acute oral--1,600
Acute dermal--6,000

Thiocyanate--It is added to household and livestock sprays to increase knockdown of flying insects.

THIMET*--see phorate

THIODAN*--see endosulfan

THURICIDE*--see Bacillus thuringiensis

*Trade name

TOXAPHENE chlorinated camphene Hercules

Acute oral--80-90
Acute dermal--780,1,075
Chronic oral--10

Fish toxicity--Very high
Bee toxicity--Low
Bird toxicity--Low

Chlorinated hydrocarbon--Used to control many insects of grain and forage crops, livestock, and vegetable and fruit crops. Used in backrubbers and as a sheep dip.

TRICHLORFON Dylox, Dipterex, Neguvon, Proxol Chemagro, Upjohn

Acute oral--560-630
Acute dermal--2,000+

Fish toxicity--Very low
Bee toxicity--Low
Bird toxicity--Low

Organic phosphate--Dipterex is used in fly baits, and Dylox is used as a spray for certain field crop, vegetable, and ornamental insects. Used for grub and caterpillar control in turfgrass.

TRITHION*--see carbophenothion

VAPONA*--see dichlorvos

ZOLONE*--see phosalone

*Trade name.

Prepared by entomologists of the Illinois Agricultural Extension Service and Illinois Natural History Survey. For additional copies, see your county extension adviser.

1978 Insect Pest Management Guide

COMMERCIAL VEGETABLE CROPS And GREENHOUSE VEGETABLES

You must be certified as a pesticide applicator to use "restricted use" pesticides. See your county extension adviser for information.

Commercial vegetable gardeners find it impossible to produce vegetables profitably unless they control insects at maximum efficiency and minimum cost. The housewife of today will not accept unsightly wormy vegetables; not only are wormy fruits and vegetables unappetizing but the waste from trimming increases food costs. Thus the commercial vegetable gardener must produce a quality product that is acceptable and safe to the consumer. Careful use of the right insecticides will enable him to do this.

Insect pest management programs, which include the wise selection of cultural, mechanical, biological, and chemical methods, are suggested for the major insect pests of vegetable crops and greenhouses. But, insecticides are still the most efficient means of managing most insects.

This suggested insecticide guide has been prepared for use by Illinois commercial vegetable farmers; it is not for home gardeners, who should use only those insecticides that are extremely safe to handle, apply, and store. Furthermore, the commercial vegetable gardener must use a wider variety of insecticides than the home gardener in order to obtain maximum insect control at the least cost.

In using insecticides, read the label and carefully follow the instructions. Do not exceed maximum rates suggested; observe carefully the interval between application and harvest, and apply only to crops for which use has been approved. Make a record of the product used, the trade name, the percentage content of the insecticide, the dilution, the rate of application per acre, and the dates of application.

Some of the insecticides suggested here can be poisonous to the applicator. In using them, the commercial grower is expected to use precautions to protect himself, his workers, and his family from undue or needless exposure.

In using this guide, always refer to the table on the next page, which lists the limitations and restrictions on use. These limitations apply to the vegetables as human food. If you use any portion of a vegetable for livestock food (tops, stalks, etc.) refer to the label for instructions as to the interval required between application and feeding.

The chemical names used in these tables may be unfamiliar to you. These names are the common coined chemical names and as such are not capitalized. Trade names are capitalized. In the table of limitations the common names are listed first. If the trade name is more commonly used, it is listed in parentheses following the common name. Throughout the tables of suggestions, however, the common name is used if there is one. In case of question, refer to the table of limitations.

These suggestions are subject to change without notification during the growing season.

Requested label clearances for a few uses of insecticides, carriers, and solvents are uncertain for 1978, since many requests have not been officially cleared. Anticipating needed changes in labeling, we began modifying these suggested uses a few years ago. Be sure to check with your county extension adviser if you are in doubt about the insecticide you plan to use. We will make announcements of label changes through the newsletters and news media to keep you up to date.

Insecticides are being classified for *general use* or *restricted use* by the U.S. Environmental Protection Agency. A person wishing to use an insecticide classified for restricted use must be certified as a private or commercial pesticide applicator by the Illinois Department of Agriculture. Contact your county extension adviser in agriculture for details on this program. Only a few insecticides have been classified at this time. More will be classified later. Insecticides bearing a restricted-use classification are identified by an asterisk (*) in this circular.

Suggestions for use of insecticides effective from a practical standpoint are based on available data. Soil textures, pH of the soil, rainfall, slope of the field, wind velocity at planting, method and accuracy of application, and other unpredictable factors affect efficiency.

This publication was prepared by entomologists of the University of Illinois College of Agriculture and the Illinois Natural History Survey.

UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN COLLEGE OF AGRICULTURE COOPERATIVE EXTENSION SERVICE
In cooperation with ILLINOIS NATURAL HISTORY SURVEY CIRCULAR 897 Urbana, Illinois, December, 1977

LIMITATIONS FOR FIELD VEGETABLES IN DAYS BETWEEN APPLICATION AND HARVEST AND OTHER RESTRICTIONS ON USE OF INSECTICIDES IN ILLINOIS

(Blank spaces indicate the material is not suggested for the specific use in Illinois)

Insecticide	Beans	Peas	Broccoli	Brussels sprouts	Cabbage	Cauliflower	Horseradish[1]	Radish[1]	Turnip[1]	Onions	Eggplant	Peppers	Tomatoes
acephate (Orthene)	...	...	...	...	...	...	...	...	...	...	...	7	...
*azinphosmethyl (Guthion)[2]	...	...	15	7	21	15	...	...	...	...	...	...	...
Bacillus thuringiensis[3]	...	...	0	0	0	0	...	...	...	...	...	...	0
carbaryl (Sevin)	0	...	3	3	3	3	3	3	3, 14A	...	0	0	0
carbofuran (Furadan)	...	...	...	...	...	...	...	...	...	...	...	21B	...
Dasanit	...	...	...	...	...	...	...	...	...	C, D	...	...	...
*demeton (Systox)	...	...	...	...	...	...	...	...	...	...	...	3	...
diazinon	...	...	5	...	7	5	...	10	10	10	...	...	1
dicofol (Kelthane)	7E	...	...	...	...	...	...	...	...	...	2	2	2
dimethoate (Cygon)	0E	0E	7	...	3	7	...	...	14	...	...	0	7
Dyfonate	...	...	C	...	C	C	...	...	...	...	...	...	...
ethion	...	...	...	...	...	...	...	...	...	C	...	...	...
malathion	1	...	3	7	7	7	7	7	3	3	3	3	1
*methomyl (Lannate)	1	1, 5A	3	3	1	3	...	...	...	...	...	10	2
mevinphos (Phosdrin)[2]	...	...	1	3	1	3	...	...	3	...	...	...	...
Monitor	...	...	21	21	35	28	...	...	...	...	...	...	...
naled (Dibrom)	...	...	1	1	1	1	...	...	4	...	...	...	...
oxydemetonmethyl (Meta-Systox R)	...	...	...	...	...	...	...	...	...	...	7F	0B	...
*parathion[2]	7	...	7	7	10	7	...	15	10	...	15	15	10
phorate (Thimet)[2]	C	...	...	...	...	...	...	...	...	...	...	...	...
rotenone	...	...	...	...	...	...	...	...	...	...	1	1	1
trichlorfon (Dylox)	...	...	...	21	21	21	...	...	28E	...	...	21	21

Insecticide	Potatoes[1]	Collards	Kale	Lettuce	Spinach	Swiss chard	Sweet corn	Cucumbers[4]	Melons[4]	Pumpkins[4]	Squash[4] Winter	Squash[4] Summer
Bacillus thuringiensis[3]	...	0	0	0	0	...	...	...	...	...	...	...
carbaryl (Sevin)	0	14	14	14	14	14	0	0	0	0	0	0
diazinon	...	10	10	10	10	12	C	7	3	...	3	7
dicofol (Kelthane)	...	...	...	...	...	...	...	2	2	2	2	2
dimethoate (Cygon)	0	14	14	14	14	14	...	...	3	...	...	...
Dyfonate	...	...	...	...	...	...	C	...	...	...	...	...
malathion	0	7	7	14	7	7	5	1	1	3	1	1
*methomyl (Lannate)	14	...	...	10	7	...	0, 3A	3	3	...	...	...
*mevinphos (Phosdrin)[2]	...	3	3	2	4	...	...	...	...	...	...	...
Mocap	...	...	...	...	...	...	C	...	...	...	...	...
naled (Dibrom)	...	4	4	1	1	1	...	...	...	...	...	...
*parathion[2]	5	10	10	21	14	21	12	15	7	10	15	15
phorate (Thimet)[2]	C	...	...	...	...	...	C	...	...	...	...	...
rotenone	...	1	1	1	1	1	...	...	...	...	...	...
trichlorfon (Dylox)	...	28G	21	28G	...	...	...	...	...	3F	...	...

* Use restricted to certified applicators only.
[1] Root crops such as radishes, turnips, carrots, horseradish, potatoes, and sugar beets should not be grown in soil where aldrin, dieldrin, or heptachlor was applied as a soil insecticide the preceding year.
[2] Use only by professional applicators or commercial gardeners.
[3] Trade names are Biotrol, Dipel, and Thuricide.
[4] Only apply insecticide late in the day after blossoms have closed to reduce bee kill.

A. If tops or stover is to be used as feed.
B. Not more than twice per season.
C. Soil applications at planting time only.
D. Do not use on green onion crop.
E. Do not use tops for feed or food.
F. Not more than three times per season.
G. Not after edible portions or heads begin to form.

REENTRY INTERVALS FOR WORKER PROTECTION

Insecticide	Hours
azinphosmethyl (Guthion)	24
demeton (Systox)	48
ethion	24
parathion	48

Workers must wear protective clothing if they enter treated fields before time intervals at right. They must also wear protective clothing for all other insecticides applied if spray has not dried or dust has not settled.

CABBAGE AND RELATED COLE CROPS[1]

Insect	Time of attack	Insecticide	Lb. of active ingredient per acre	Placement	Timing of application
Cabbage maggot[2] (NHE-44)	All season	diazinon Dyfonate	3 2	Broadcast	Disk in just before planting. Use only for cabbage, cauliflower, and broccoli.
		diazinon granules	1	Furrow	At time of planting; on turnips a drenching spray of 1 lb. diazinon should be applied 30 days following treatment.
		*azinphosmethyl diazinon	3 oz. W.P. or 2 oz. E.C. per 50 gal. transplant water 4 oz. per 50 gal. transplant water		6 fluid oz. transplant water per plant.
Aphid (NHE-47) Thrips (NHE-48)	All season	*azinphosmethyl dimethoate malathion *mevinphos *parathion	¾ 0.3 1 ¼ 0.4	Foliage	When aphids appear, but before leaves begin to curl.
Diamond-back moth larva; imported cabbage worm; cabbage looper (NHE-45)	All season	*Bacillus thuringiensis*[3] *methomyl Monitor	See rates on label 0.45-0.9 1	Foliage	When small worms first appear, and about every 5 to 7 days thereafter. Thorough spray coverage of foliage is important.
Cutworm	At planting	trichlorfon	1	Soil	At planting, at base of plant or as needed when damage first occurs.
Flea beetle and leafhopper	All season	carbaryl	1½	Foliage	As needed.

* Use restricted to certified applicators only.
[1] Root crops such as radishes, turnips, carrots, potatoes, and sugar beets should not be grown in soil where aldrin, dieldrin, or heptachlor was applied as a soil insecticide the preceding year.
[2] Maggots are resistant to diazinon in some areas of Illinois.
[3] No time limitations.
E.C. = emulsion concentrate; W.P. = wettable powder.

COLLARDS, KALE, LETTUCE, SPINACH, SWISS CHARD

Insect	Time of attack	Insecticide	Lb. of active ingredient per acre	Placement	Timing of application
Aphid (NHE-47)	All season	diazinon dimethoate *mevinphos naled *parathion	½ 0.3 ¼ 1 0.4	Foliage	As needed.
Cutworm	On seedling plants	trichlorfon	1	Base of plant and soil	When first damage appears.
Leafhopper	All season	carbaryl dimethoate malathion	1½ 0.3 1	Foliage	When first leafhoppers appear and as needed.
Caterpillar (NHE-45)	All season	*Bacillus thuringiensis*[1] naled	See rates on label 1	Foliage	When small worms first appear and every 5 to 7 days thereafter.
Leaf miner	All season	diazinon dimethoate *parathion	½ 0.3 0.4	Foliage	When first miners are observed.
Flea beetle	All season	carbaryl rotenone	1 ¼	Foliage	As needed.

* Use restricted to certified applicators only.
[1] No time limitations.

BEANS

Insect	Time of attack	Insecticide	Lb. of active ingredient per acre	Placement	Timing of application
Seed maggot (NHE-27)	All season	diazinon 50% W.P.[1] Lorsban 25% W.P.[1]	3/5 oz./bu. 2 oz./bu.	Seed Seed	Treat seed no longer than 3 months before planting.
		phorate granules	1½	Soilband	Place on either or both sides of row at planting but not in contact with seed.
Bean leaf beetle (NHE-67)	Early and late season	carbaryl malathion	1 1	Foliage	When feeding first appears and weekly for 2 or 3 applications as needed.
Leafhopper (NHE-22) and plant bug (NHE-68)	All season	carbaryl dimethoate malathion *methomyl	1 0.3 1 0.45	Foliage	Before plants become yellow and stunted. Repeat applications at weekly intervals as necessary.
		phorate granules	1½	Soilband	As for seed maggot.
Mexican bean beetle	Midseason and late season	carbaryl malathion	½ 1	Foliage	When occasional leaves show lacework feeding.
		phorate granules	1½	Soilband	As for seed maggot.
Aphid (NHE-47)	All season	dimethoate malathion	0.3 1	Foliage	Usually applied when a few aphids can be found on each plant, but before leaves begin to curl and deform.
		phorate granules	1½	Soilband	As for seed maggot.
Blister beetle (NHE-72)	Midseason and late season	carbaryl	1½	Foliage	As needed.
Corn earworm (NHE-33) Corn borer	Late season	carbaryl *methomyl *parathion	1½ 0.45 ½	Foliage	As needed, but usually after September 1. Worms may be present before bloom.
Mites	Midseason and late season	dicofol dimethoate malathion	0.4 0.3 1	Foliage	As needed, but especially during drouthy periods particularly if carbaryl has been used on crops.
		phorate granules	1½	Soilband	As for seed maggot.

* Use restricted to certified applicators only.
[1] No restrictions when used as recommended.

CUCUMBERS AND OTHER VINE CROPS[1]

Insect	Time of attack	Insecticide[2]	Lb. of active ingredient per acre	Placement	Timing of application[2]
Striped and spotted cucumber beetles (NHE-46)	Seedling to mature plants	carbaryl *parathion	1 ½	Foliage	When beetles first appear; as often as necessary thereafter.
Aphid (NHE-47)	All season	diazinon dimethoate[3] malathion *parathion	½ 0.3 1 ½	Foliage	When aphids become noticeable.
Squash bug (NHE-51)	All season	*parathion trichlorfon[4]	½ 1	Foliage	Do not apply until first eggs are found hatching (about June 15 to July 15).
Leafhopper	July-August	malathion dimethoate[3]	1 0.3	Foliage	As needed.
Squash vine borer	June-September	carbaryl	1	Base of stem for 3 ft.	Weekly applications when vines begin to run—usually 5 applications.
Pickle worm	August-September	carbaryl	1	Foliage	Weekly applications, beginning in late August.
Mites	July-September	dicofol malathion *parathion	½ 1 ½	Foliage	As needed.
Cutworm (NHE-77)	April-June	carbaryl	2	Base of plants	As needed.

* Use restricted to certified applicators only.
[1] Pumpkins should not be grown on soil that has been treated with aldrin, dieldrin, or heptachlor the preceding year.
[2] Spray vine crops with insecticide only late in the day after blossoms have closed to reduce bee kill.
[3] Do not use dimethoate on cucumbers.
[4] Pumpkin is the only vine crop for which trichlorfon should be used for squash bug control. Apply only once per season.

TOMATOES AND EGGPLANT

Insect	Time of attack	Insecticide	Lb. of active ingredient per acre	Placement	Timing of application
Cutworm (NHE-77)	Early and midseason	carbaryl trichlorfon	2 1	Base of plants or foliage	As needed.
Flea beetle	May-June	carbaryl rotenone	2 0.2-0.4	Foliage	Apply every week as long as needed.
Aphid (NHE-47)	May-July	diazinon dimethoate[1] malathion *parathion	¼ 0.3 1 0.4	Foliage	As needed, but before leaves curl.
Cabbage looper	July-September	*Bacillus thuringiensis* *methomyl	See rates on label 0.45-0.9	Foliage	When loopers are present.
Corn earworm Corn borer	July-September; occasionally in June	carbaryl *methomyl[1]	2 0.45-0.9	Foliage	Add to weekly applications of fungicide sprays beginning at first fruit set. If spraying is infrequent, use 6 lb. of toxaphene.
Hornworm	July-September	carbaryl trichlorfon	2 1	Foliage	When first small worms appear.
Mites	July-September	carbophenothion dicofol malathion *parathion	1 ½ 1 0.4	Foliage	As needed.
Russet mite	July-September	*parathion sulfur dust[2] sulfur spray[2]	0.4 10 10	Foliage	As needed.
Blister beetle (NHE-72)	June-September	carbaryl *parathion	1½ ¼	Foliage	As needed.
Fruit fly and picnic beetle	August-October	diazinon spray diazinon granules	½ 1	Foliage	When flies or beetles first appear.
		pyrethrin dust[2]	1	Foliage	Apply to hamper immediately after it is filled.

* Use restricted to certified applicators only.
[1] Use cleared only on tomatoes. [2] No limitations on use.

PEPPERS

Insect	Time of attack	Insecticide	Lb. of active ingredient per acre	Placement	Timing of application
Aphid (NHE-47)	May-July	dimethoate demeton *methomyl oxydemetonmethyl acephate	0.3 ⅜ 0.45 ½ ½	Foliage	Only when aphids are present. Add to borer spray when it is being used.
Corn borer	Late season	carbaryl acephate	2 1	Foliage and fruit	When fruit is present on plant. Apply every 5 days when borers are present.
		carbofuran	2-3	Soilband to transplant	Make 2 applications; first, 3 weeks after transplant, second, 5 weeks later.

* Use restricted to certified applicators only.

ASPARAGUS

Insect	Time of attack	Insecticide	Lb. of active ingredient per acre	Placement	Timing of application
Asparagus beetle (NHE-49)	Early and mid-season on spears and ferns	carbaryl[1] malathion[1] rotenone[1]	1½ 1 0.2-0.4	Spears and ferns Spears	As needed, not more often than every 3 days. As needed.

[1] One-day restriction between last application and harvest.

SWEET CORN

Insect	Time of attack	Insecticide	Lb. of active ingredient per acre	Placement	Timing of application
Soil insects (NHE-26, 27, 43)	April-August	diazinon Dyfonate Mocap phorate	1 1 1 1	Row	Apply on soil surface behind planter shoe and ahead of press wheel.
Cutworm (NHE-38)	April-June	carbaryl[1] carbaryl bait	2-3 1	Base of plants	When first damage appears.
Flea beetle (NHE-36)	April-July	carbaryl[1]	1½	Foliage	As necessary.
Japanese beetle (NHE-32)	July-September	carbaryl[1]	1	Ear zone	As necessary.
Corn borer	June-September	carbaryl[1] *methomyl	2 0.45	Foliage	Make first application when tassel ratio is 30 to 40. Repeat every 4 to 5 days as long as field has 20 or more unhatched egg masses per 100 plants.
Corn earworm[2] (NHE-33)	June-September	carbaryl[1] *methomyl	2 0.45	Ear zone	Market corn: At first silk and every 2 to 3 days for 5 to 8 applications. On very early or late planted corn, treatment may be necessary before silking when eggs are being laid on stalks and flag leaves. Canning corn: At 30 to 50% silk and every 3 days thereafter until corn is within 8 to 12 days of harvest.
Sap beetle (NHE-10) Picnic beetle	July-September	carbaryl[1] diazinon malathion *parathion	2 1 1 ½	Foliage	When adults first appear in field; usually between pollen-shedding and silk-drying.
Corn leaf aphid (NHE-29)	July-September	malathion *parathion	1 ½	Foliage	As needed to produce attractive ears for fresh market.
Fall armyworm	July-September	*methomyl *parathion	0.45 ½	Foliage	Apply to ear zone when whorl feeding is evident.

* Use restricted to certified applicators only.
[1] During pollen shed, apply carbaryl as late in the day as possible (preferably after 4 p.m.) to reduce bee kill.
[2] Addition of 0.5 to 0.75 pound of parathion or 0.25 to 0.45 pound of methomyl to carbaryl improves earworm control.

ONIONS

Insect	Time of attack	Insecticide	Lb. of active ingredient per acre	Placement	Timing of application
Onion maggot (NHE-50)	All season	diazinon W.P. ethion W.P.	½-1 for 40-50 lb. of seed 1 for 40-50 lb. of seed	Seed	Seed treatment for set onions only. Use lighter dosage of diazinon on sandy, highly mineral soils.
		Dasanit granules diazinon granules Dyfonate ethion granules	1 ½-1 1 ½-2	Furrow	Use 1 lb. active ingredient per acre for rows 12″ apart; ¾ lb. for rows 18″ apart; ½ lb. for rows 24″ apart. Up to twice these amounts are needed for ethion on muck soils. Do not use Dasanit or Dyfonate on green onions.
		diazinon	2	Broadcast	Preplanting; disk into upper 1 to 2 inches of soil. Supplement with foliage spray below.
		diazinon malathion	⅓ 1	Foliage	Supplemental to soil treatment. Make first application when first adult flies are seen; make another 1 week later. From then on only as necessary.
Thrips (NHE-48)	Midseason and late season	diazinon malathion	½ 1	Foliage	When injury first appears and every 10 days as necessary.

POTATOES[1]

Insect	Time of attack	Insecticide	Lb. of active ingredient per acre	Placement	Timing of application
Flea beetle	May-July	carbaryl *methomyl	1 0.45	Foliage	When first damage appears on leaves, and repeat as needed.
Colorado potato beetle	May-July	carbaryl	1	Foliage	As needed.
Potato leafhopper (NHE-22)	May-July	carbaryl dimethoate *methomyl	1 0.3 0.45	Foliage	Weekly applications when leafhoppers first appear.
		phorate granules	2-3	Soilband	Place on either or both sides of row at planting but not in contact with seed. Use lower rate on sandy soils and heavier rate on heavy soils. Do not use on muck soils.
Aphid (NHE-47)	All season	dimethoate malathion *methomyl *parathion	0.3 1 0.45 ¼	Foliage	As needed.
		phorate granules	2-3	Soilband	As for leafhoppers.
Blister beetle (NHE-72)	All season	carbaryl	1½	Foliage	As needed.
Wireworm (NHE-43) White grub (NHE-23)	All season	phorate granules	2-3	Soil	Preplanting, disk in; or use as soilband at planting.
Grasshopper (NHE-74)	July-September	carbaryl	¾	Foliage	As needed, control in fence rows, roadsides, ditch banks, etc., before migration.

* Use restricted to certified applicators only.

[1] Potatoes should not be grown in soil where aldrin, dieldrin, or heptachlor was applied as a soil insecticide the preceding year.

PEAS

Insect	Time of attack	Insecticide	Lb. of active ingredient per acre	Placement	Timing of application
Caterpillars including loopers	June	*methomyl	½-1	Foliage	Before harvest if worms are present.
Aphids	May-June	dimethoate	⅓	Foliage	As needed.

* Use restricted to certified applicators only.

Limitations for Greenhouse Tomatoes

Insecticide	Tomatoes
endosulfan (Thiodan)	15 hours
malathion	15 hours
metaldehyde	As bait applied only to soil
naled (Dibrom)	1 day
*parathion[1]	10 days

* Use restricted to certified applicators only.

[1] Do not use aerosols that contain parathion, tepp, or the propellant methyl chloride in greenhouses connected to living quarters.

GREENHOUSE TOMATOES

Insect	Insecticide[1]	Dosage and formulation	Application
Aphid Whitefly	malathion aerosol	1 lb. 10% aerosol per 50,000 cu. ft.	In a closed greenhouse above plants.
	naled vapor	5 oz. of 4% E.C. per 50,000 cu. ft.	Apply on steampipes.
	*parathion aerosol	1 lb. 10% aerosol per 50,000 cu. ft.	In a closed greenhouse above plants.
Mealybug Spider mite Russet mite Thrip		Use malathion or parathion aerosol as suggested for aphid and whitefly.	
Armyworm Cabbage looper Cutworm Tomato fruitworm	malathion aerosol	1 lb. 10% aerosol per 50,000 cu. ft.	In a closed greenhouse above plants.
	*parathion aerosol	1 lb. 10% aerosol per 50,000 cu. ft.	In a closed greenhouse above plants.
Slug	metaldehyde	Commercially prepared bait or spray	To mulch on soil surface. Do not contaminate edible parts.

* Use restricted to certified applicators only.
[1] See page 7 for limitations between application and harvest.

FOR ADDITONAL INFORMATION

Obtain the following circulars on insect control from the Office of Agricultural Publications, 123 Mumford Hall, Urbana, Illinois 61801.

Circular 899, Insect Pest Management Guide — Field and Forage Crops

Circular 900, Insect Pest Management Guide — Home, Yard, and Garden

Circular 1076, Turfgrass Pest Control

Leaflets describing the life history, biology, and habits of some of the insects mentioned can be obtained from the offices of county extension advisers or by writing to Entomology Extension, 169 Natural Resources Building, Urbana, Illinois 61801. These are indicated by an NHE number in the tables.

FOR YOUR PROTECTION

Always handle insecticides with respect. The persons most likely to suffer ill effects from insecticides are the applicator and his family. Accidents and careless, needless overexposure can be avoided. Here are a few easy rules that if followed will prevent most insecticide accidents:

1. Wear rubber gloves when handling insecticide concentrates.
2. Do not smoke while handling or using insecticides.
3. Keep your face turned to one side when opening insecticide containers.
4. Leave unused insecticides in their original containers with the labels on them.
5. Store insecticides out of reach of children, irresponsible persons, or animals; store preferably in a locked cabinet.
6. Triple-rinse and bury or burn all empty insecticide containers or take to an approved sanitary landfill.
7. Do not put the water-supply hose directly into the spray tank.
8. Do not blow out clogged nozzles or spray lines with your mouth.
9. Wash with soap and water exposed parts of body and clothes contaminated with insecticide.
10. Do not leave puddles of spray on impervious surfaces.
11. Do not apply to fish-bearing or other water supplies.
12. Do not apply insecticides, except in an emergency, to areas with abundant wildlife or to blossoming crops visited by bees. Avoid drift onto blossoming crops or onto bee hives.
13. Do not apply insecticides near dug wells or cisterns.
14. Do not spray when weather conditions favor drift.
15. Observe all precautions listed on the label.
16. To avoid bee kill, apply insecticides after bee activity has been completed for the day; use the least toxic materials. *Warn beekeepers that you are applying insecticides.*

1978 Insect Pest Management Guide

LIVESTOCK and LIVESTOCK BARNS

You must be certified as a pesticide applicator to use "restricted use" pesticides. See your county extension adviser for information.

Livestock producers must manage insect pests to attain maximum production. Flies, lice, mites, ticks, and grubs irritate animals and some suck their blood. This reduces meat, milk, and egg production. On occasion, individual animals have been killed by attacks of large numbers of pests like horse flies, lice, and mites. Several of these pests transmit diseases from animal to animal. Losses from pests each year cost Illinois farmers millions of dollars. A livestock producer does not need to share his profits with insects — they can be managed effectively.

Insect pest management programs, which include the wise selection of cultural, mechanical, biological, and chemical methods, are suggested for the major insect pests of livestock and livestock barns. Insecticides are still the most efficient means of managing most insect problems. Only the safest, most effective insecticides are suggested for each specific insect on each type of livestock. Other insecticides that may have label approval for use on livestock are not included because they are less effective or more toxic or present potential residue problems. Blank spaces in the table of limitations (page 4) mean we do not suggest the insecticide for that specific purpose in Illinois.

In using insecticides read the label and follow instructions. Do not exceed the rates suggested; observe the interval between application and slaughter and apply only to those animals for which use has been approved. Keep a record of the insecticide used, trade name, percentage of active ingredients, dilution, rate of application, and dates of application. If you are ever questioned, you have the records.

Most of the insecticides are suggested for use as emulsion concentrates since these are the easiest formulations to handle. Wettable powders can be substituted if the finished spray is well agitated.

Chemical names in these tables may be unfamiliar to you. These names are the common coined chemical names and are not capitalized. Trade names are capitalized. In the table of limitations (page 4) common names are listed first. If the trade name is more commonly used, it is listed in parentheses with the common name. In the tables of suggested insecticides on pages 2 and 3, only the common name is used if there is one. In case of question, refer to the table of limitations.

These suggestions are printed annually. Always use the current year's issue. Labels may be cancelled and a product removed from the market at any time. New labels may be granted. We attempted to anticipate any further label changes, but there may be an occasional change. Check with your county extension adviser if you are not sure about the insecticide you plan to use. We will make announcements of label changes through the news media to keep you up to date.

Insecticides are being classified for *general use* or *restricted use* by the U.S. Environmental Protection Agency. Only a few insecticides have been classified for restricted use at this time. There are no insecticides listed in this circular that have a restricted use classification. A person wishing to use an insecticide classified for restricted use must be certified as a private or commercial pesticide applicator by the State of Illinois. Contact your county extension adviser in agriculture for details on this program.

The Illinois Department of Public Health has announced it is illegal for dairymen to apply or store chlorinated-hydrocarbon insecticides — aldrin, chlordane, dieldrin, endrin, lindane, or heptachlor — on their farms, except for use in farm residences. Previously use of DDT was prohibited except by permit from the Illinois Department of Agriculture or Public Health.

Suggestions for use of insecticides are based on available data. Rainfall, temperature, and many other factors affect efficiency of insecticides. Report the details of control failures to us.

These suggestions were prepared by entomologists of the University of Illinois College of Agriculture and the Illinois Natural History Survey.

Leaflets describing the life history, biology, and habits of some of the insects mentioned can be obtained from offices of county extension advisers or by writing to Entomology Extension, 169 Natural Resources Building, Urbana, Illinois 61801. These are indicated by an NHE number in the tables.

Obtain the following circulars on insect control from the Office of Agricultural Publications, 123 Mumford Hall, Urbana, Illinois 61801.

Circular 899, Insect Pest Management Guide — Field Crops
Circular 900, Insect Pest Management Guide — Home, Yard and Garden
Circular 925, Insect Pests of Cattle

UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN **COLLEGE OF AGRICULTURE** **COOPERATIVE EXTENSION SERVICE**
In cooperation with ILLINOIS NATURAL HISTORY SURVEY **CIRCULAR 898** **Urbana, Illinois, December, 1977**

DAIRY CATTLE, BEEF CATTLE, SWINE, AND SHEEP

(Refer to table of limitations on back page before using insecticides)

	Insect	Insecticide	Amount per 100 gal. water or as directed	How to apply
Dairy Cattle	Lice and mange (NHE-18)	crotoxyphos 14.4% E.C.	6 pt.	1 gal. per animal. Spray entire animal to saturation. Make 2 treatments 14 days apart.
		Ciovap {crotoxyphos 10.0% + dichlorvos 2.5% E.C.	2 gal.	
Pastured cattle only	Face flies[1] (NHE-106) Horn flies[1] (NHE-59) Stable flies[4] (NHE-61)	crotoxyphos 2.0% O.[2]	Ready to use	1-2 oz. per animal; 2-4 times per week.[3]
		Ciovap 1.25% O.[2]	Ready to use	
		Ciovap 12.5% E.C.	1 qt. per 3 gal. water	1 pt. per animal per week or 1-2 oz. per animal 2-4 times per week from small hand sprayer or mist blower.[3]
	Horn flies[1] Stable flies[4]	dichlorvos 1.0% O.[2]	Ready to use	1-2 oz. per animal daily.[3]
		pyrethrin 0.1% + synergist O.[2]	Ready to use	
	Horse and deer flies[5] (NHE-60)	pyrethrin 0.5% + synergist O.[2]	Ready to use	2 oz. per animal 3 times per week.[3]
		pyrethrin 1% + synergist E.C.	10 gal.	1-2 qt. per animal every 3 days.[3]
	Horn flies	crotoxyphos 3.0% D. or 1.0% O. coumaphos 1.0% D. or 1.0% O. stirofos 3.0% D. or 1.0% O. dichlorvos 0.25% O. ronnel 1.0% O.	In dust bags or face and back oilers	Use only in exits of milk parlors, barns, or lanes. Apply daily. Only partially controls face and stable flies. Helps suppress lice infestations.
Beef Cattle	Lice and mange (NHE-18)	crotoxyphos 14.4% E.C.	6 pt.	1 gal. per animal. Spray animal to saturation. Make 2 applications 14 days apart.
		Ciovap 12.5% E.C.	2 gal.	
	Lice	ronnel 24.5% E.C.	1 qt. per gal. water	Apply 1 oz. per 100 lb. body weight. Maximum of 8 oz. per animal. Pour on topline from shoulders to hips.
Pastured cattle only	Face flies[1] Horn flies[1]	Ciovap 12.5% E.C.	1 qt. per 3 gal. water	1-2 oz. per animal; 2-4 times per week from a mist blower.[3]
				1 pt. per adult animal per week.[3]
	Stable flies[4]	crotoxyphos 2.0% O.[2]	Ready to use	1-2 oz. per animal; 2-4 times per week from automatic sprayer.[3]
		Ciovap 1.25% O.[2]	Ready to use	
	Horn flies[1]	Dust bags and oilers:	Various insecticides are approved for use in face oilers, back oilers, and dust bags. Force treat if possible, but always place in location for greatest use. Only partially controls stable and face flies. Keep device well charged and in good working order.	
	Horse and deer flies[1]	Use as directed for dairy cattle above.		
	Grubs	Systemic insecticides like coumaphos, crufomate, fenthion, phosmet, and trichlorfon, as sprays provide excellent control of grubs and good control of lice. Use only on *native beef cattle* in herds having a history of grub problems. Treat only those animals between 4 months and 2½ years of age. Apply during August or September in the southern half of the state and in September or October in the northern half of the state. Animals in confinement are not attacked by ox warble flies.		
Swine	Mange and lice	malathion 50–57% E.C.	1 gal.	2-4 qt. per animal. Spray animal to saturation. Make 2 applications 14 days apart.
	Lice	fenthion 3% O.	Ready to use	Apply ½ oz. per 100 lb. body weight. Pour on topline from neck to rump.
		ronnel 5% G.	Ready to use	Apply ½ lb. per 100 sq. ft. of bedding.
Sheep	Keds, lice, and scab (NHE-53)	toxaphene 60% E.C.	3 qt.[5]	Spray animal to saturation or use in dipping vat for scab.[6]
	Keds and lice	diazinon 50% W.P.	½ oz. per 3 gal. water	Apply 1 qt. per animal from sprinkling can over back, head, and neck.[7]
		ronnel 24.5% E.C.	Ready to use	Apply 3cc (ml) as a spot-on along center line of back.[8]

Note: E.C. = emulsion concentrate, O. = oil solution, W.P. = wettable powder, D. = dust, G. = granule.

[1] Place cattle in barns or sheds to avoid attack by face flies, horn flies, horse flies, and deer flies.

[2] The same dosage of a water-base spray may be used.

[3] Spray head, back, sides, belly, and legs carefully. Start treatments in late May or early June and continue to September.

[4] Remove decaying straw, hay, manure, and feed from barns and lots, and spread to dry each week or cover manure pile with black plastic so stable fly breeding will be reduced.

[5] Add 2 pounds of detergent per 100 gallons of spray for better wetting effects.

[6] Official scab eradication treatment used by the State Department of Agriculture. Involves 2 dippings 10–14 days apart. Isolate and treat incoming animals before introducing them into the flock.

[7] Stir the diazinon suspension frequently.

[8] Use on short-wooled sheep, no more than 6 weeks after shearing.

GOATS, HORSES, CHICKENS, LIVESTOCK BARNS, AND SHEDS

(Refer to table of limitations on back page before using insecticides)

	Insect	Insecticide	Amount per 100 gal. water or as directed	How to apply
Goats *Pastured goats only*	Face flies[1] Stable flies	Ciovap 12.5% E.C.	1 qt. per 3 gal. water	Apply 1 pt. per animal per week.
	Horse and deer flies[1]		Use pyrethrin as directed for dairy cattle.	
	Lice	Ciovap 12.5% E.C.	2 gal.	Apply 2-4 qt. per animal. Repeat in 14 days.
Horses *Pastured horses only*	Face flies[1] Stable flies[2]	stirofos 1.0% + .09% synergized pyrethrin + 1.3% repellent O.	Ready to use	Apply 1-2 oz. as a wipe on or spray over entire animal 2-4 times per week.[3]
	Horse and deer flies[1]		Use water-base spray of pyrethrin as for dairy cattle.[3]	
	Black flies[1]	petroleum jelly	Ready to use	Apply a thin coating on inside of ears. Use stirofos as suggested above for flies.
	Lice	malathion 4.0-5.0% D.	4-3 tbl. per animal	Apply on back and neck of animals. Repeat in 14 days.
Chickens	Northern fowl mites, common red mites, bedbugs, and lice (NHE-54)	carbaryl 80% W.P.	4 oz. per 5 gal. water	Spray birds using 1 gal. per 100 birds for fowl mites and lice. Spray roosts, walls, and around nests for red mites and bedbugs. Dust of 5% carbaryl, 0.5% coumaphos, 4% malathion, or 3% stirofos may be used on litter for control of northern fowl mites and lice. Keep wild birds from entering or nesting in poultry houses.
		stirofos 50% W.P.	6.5 oz. per 5 gal. water	
		coumaphos 25% W.P.	3 oz. per 5 gal. water[4]	
		malathion 50–57% E.C.	5 oz. per 5 gal. water[4]	
		stirofos 24% E.C.[6]	13 oz. per 5 gal. water	
		Ravap {stirofos 23% + dichlorovos 6% E.C.	13 oz. per 5 gal. water	
Residual Sprays for Livestock Barns and Sheds[2]	House flies (NHE-16, 88) Stable flies, and other flies	fenthion 45% E.C.	3 gal.	Start treatments in June and maintain good sanitation. Apply 2 gal. per 1,000 sq. ft. or to runoff to ceilings, walls, and support posts, and outside around doors and windows. Lasts about 4-6 weeks.[5]
		diazinon 50% W.P.	16 lb.	Lasts about 2-3 weeks.[5] Apply as for fenthion. Do not use in dairy or poultry barns.
		dimethoate 23% E.C.	4 gal.	Lasts about 3-4 weeks.[5] Apply as for fenthion.
		stirofos 24% E.C.[6]	4 gal.	Lasts about 2-4 weeks.[5] Apply as for fenthion.
		Ravap 29% E.C.	4 gal.	
		ronnel 24.5% E.C.	4 gal.	Lasts about 1-2 weeks.[5] Apply as for fenthion.
Space Sprays for Feed Lots and Sheds[2]	House flies Stable flies, and other flies	dichlorvos 23% E.C.	2 gal.	Apply 5 gal. per acre with mist blower over animals and pens every 3 to 7 days.
		naled 37% E.C.[7]	1 gal.	Apply as for dichlorvos.
		pyrethrin E.C.	Dilute to 0.1% with water	Apply as for dichlorvos.
Baits as Supplements for Livestock Barn and Shed Sprays[2]	House flies	dichlorvos 23% E.C.	4 oz. per 1 gal. corn sirup + ½ gal. warm water	Apply to favorite fly-roosting areas from tank sprayer as needed to supplement residual spray treatment.
		naled 37% E.C.	2 oz. per 1 gal. corn sirup + ½ gal. warm water	Apply as for dichlorvos.

Note: E.C. = emulsion concentrate, O. = oil solution, W.P. = wettable powder, D. = dust.

[1] Place horses or goats in barns or sheds to avoid attack by face flies, black flies, horse flies, deer flies, and mosquitoes.

[2] Good sanitation is the basic step in barn fly control (house and stable flies). Remove manure, decaying straw, hay and feed, and spread to dry each week or cover manure pile with black plastic. Leave a 4–6 in. residue of manure in the pits or pens if the interval between cleanups is more than 1 week.

[3] Spraying may upset horses. Avoid getting spray into the animal's eyes. Use rubber gloves when wiping on insecticides.

[4] Double the amount of insecticide-to-water ratio for spraying roosts, walls, and around nests.

[5] Lasting effects are shortened during periods of hot, dry weather.

[6] A wettable powder formulation can be substituted if the finished spray is well agitated.

[7] Temporary stinging of eyes may occur from mist but this is not hazardous. Rinse equipment thoroughly after use to avoid corrosion.

LIMITATIONS FOR SUGGESTED INSECTICIDES APPLIED TO LIVESTOCK OR IN LIVESTOCK BARNS

(Blank spaces in the table denote that the material is not suggested for that specific use in Illinois)

	Dairy		Beef		Swine		Sheep		Goats		Horses		Chickens	
	Animals	Barns	Animals	Barns	Animals	Barns	Animals	Barns	Animals	Barns	Animals	Barns	Birds	Barns
carbaryl (Sevin)	...	...	...	...	...	...	...	...	...	...	...	...	A,B	A,B
Ciovap	C,D,E,F	...	C,D,E,F	...	...	...	...	...	C,D,F,G	...	...	...	...	...
coumaphos (Coral)	C, D	...	C,D,E	...	...	...	...	...	...	...	...	...	B	B
crotoxyphos (Ciodrin)	C,D,E,F	...	C,D,E,F	...	...	...	...	...	...	...	...	...	...	...
crufomate (Ruelene)	...	...	C,D,E,H	...	...	...	...	...	...	...	...	...	...	...
diazinon	...	...	...	D,I	...	D,I	C,D,J	D,I	...	...	...	D,I	...	...
dichlorvos (DDVP) (Vapona)	C,D	K,L	C,D	K,L	...	K,L	...	K,L	...	K,L	...	K,L	...	K
dimethoate (Cygon)	...	D,I	...	D,I	...	D,I	...	D,I	...	D,I	...	D,I	...	D,I
fenthion (Baytex) (Tiguvon)	...	D,I	C,D,E,M	D,I	N,O	D,I	...	D,I	...	D,I	...	D,I	...	B
malathion	...	...	...	...	C,D	...	...	...	...	...	C,D	...	B	B
naled (Dibrom)	...	C,K,L	...	K,L	...	K,L	...	K,L	...	K,L	...	K,L	...	K
phosmet (Prolate)	...	...	C,D,E,P	...	...	...	...	...	...	...	...	...	...	...
pyrethrin	C	L	C	L	...	L	...	L	C	L	C	L	...	...
Ravap	...	D,I	...	D,I	...	D,I	...	D,I	...	D,I	...	D,I	B,Q	B
ronnel (Korlan)	C,D	D,I	C,D	D,I	C,O	D,I	C,D,R	D,I	...	D,I	...	D,I	...	B
stirofos (Rabon)	C,D	D,I	...	D,I	...	D,I	...	D,I	...	D,I	C,D	D,I	B,Q	B
toxaphene	...	...	...	...	...	...	C,R	...	...	...	...	...	...	...
trichlorfon (Neguvon)	...	...	C,D,E,N	...	...	...	...	...	...	...	...	...	...	...

A. Do not apply within 7 days of slaughter and do not treat nesting material. Do not repeat within 4 weeks.
B. Gather eggs before treatment and do not contaminate feed and water.
C. Do not contaminate feed, water, milk, or milking equipment.
D. Do not apply in conjunction with the feeding of phenothiazine or organophosphate insecticides.
E. Do not treat: animals less than 6 months old; sick or stressed animals within 10 days of shipping animals; or in a confined, nonventilated area.
F. Do not apply within 1 day of slaughter and do not treat Brahman cattle.
G. Do not repeat more often than every 7 days.
H. Do not apply within 7 days of slaughter. Do not repeat applications within 21 days.
I. When used as a spray, remove animals before treating barn. Do not contaminate feed, water, eggs, milk, or milking equipment. Do not use in milk storage rooms. Do not apply to animals.
J. Do not apply within 14 days of slaughter. Do not treat lambs less than 2 weeks old.
K. As a bait. Do not apply within reach of animals or in milk rooms. Do not contaminate feed, water, eggs, milk, or equipment.
L. As a space spray in feed lots, corrals, or pens; may be applied with animals present, but avoid direct application to exposed feed and water. Do not apply in conjunction with the feeding of phenothiazine or the feeding or use as animal or shelter treatments of organophosphate or carbamate insecticides.
M. Do not apply within 45 days of slaughter.
N. Do not apply within 14 days of slaughter.
O. Do not use in conjunction with organophosphate or carbamate insecticides.
P. Do not apply within 21 days of slaughter. Do not repeat treatment within 7 days.
Q. Do not repeat more often than every 14 days. If used on walls for fly control, do not apply to birds.
R. Do not apply within 28 days of slaughter.

FOR YOUR PROTECTION

Here are a few easy rules that if followed will prevent most insecticide accidents:

1. Wear rubber gloves when handling insecticide concentrates.
2. Do not smoke while handling or using insecticides.
3. Keep your face turned to one side when opening insecticide containers.
4. Leave unused insecticides in their original containers with the labels on them.
5. Store insecticides out of reach of children, irresponsible persons, or animals; store preferably in a locked cabinet or room, away from food, feed, or water.
6. Triple rinse and bury or burn empty insecticide containers, or take to an approved sanitary landfill.
7. Do not put the water-supply hose directly into the spray tank.
8. Do not blow out clogged nozzles or spray lines with your mouth.
9. Wash with soap and water exposed parts of body and clothes contaminated with insecticide.
10. Do not leave puddles of spray on impervious surfaces.
11. Do not apply to or allow runoff into fish-bearing or other water supplies. Do not allow treated animals in fish-bearing waters or other water supplies until the spray has dried.
12. Do not apply insecticides, except in an emergency, to areas with abundant wildlife or to blossoming crops visited by bees. Avoid drift onto blossoming crops and onto beehives.
13. Do not apply insecticides near dug wells or cisterns.
14. Do not spray when weather conditions favor drift.
15. Follow all directions and precautions listed on the label.

1978 Insect Pest Management Guide

FIELD and FORAGE CROPS

You must be certified as a pesticide applicator to use "restricted use" pesticides. See your county extension adviser for information.

Federal and State Laws

The U.S. Environmental Protection Agency is classifying pesticides as either "general" use or "restricted" use. Anyone applying a restricted-use pesticide must be certified. Only a few pesticides have been classified at this time.

Commercial applicators who apply restricted-use pesticides must be certified. Commercial applicators include not only persons applying a pesticide for hire but also governmental personnel, chemical company representatives, and others involved in demonstrational, regulatory, and public health pest control. Certification as a commercial applicator requires passing a written examination administered by either the Illinois Department of Agriculture or the Department of Public Health.

Private applicators who use restricted-use pesticides "for the purpose of producing any agricultural commodity on property owned or rented by him or as exchange labor (no compensation) on the property of another" must also be certified, either by attending an educational training program or by passing an examination.

Educational training programs for farmers (private applicators) and commercial pesticide applicators are conducted by the Cooperative Extension Service to prepare persons for certification. For additional information, consult your county extension adviser. The actual certification and the issuing of permits or licenses are handled by the Illinois Department of Agriculture or the Department of Public Health.

The chlorinated hydrocarbons — aldrin, chlordane, dieldrin, endrin, heptachlor, and lindane — cannot be used on dairy farms except around the farm residence. This ruling was adopted by the Illinois Department of Public Health.

In 1974 the U.S. Environmental Protection Agency (EPA) suspended the manufacture of aldrin and dieldrin for agricultural purposes. Uses of heptachlor and chlordane on corn were suspended by the EPA on August 1, 1976. However, any product containing heptachlor or chlordane that was formulated before July 29, 1975, may be used for any use listed on the product label. The heptachlor seed-treatment label was unaffected by the suspension order, so heptachlor can continue to be used for this purpose.

Insecticides and Classifications

At the time this publication was in preparation, only a few of the insecticides listed below had been classified for either "restricted" or "general" use by the EPA. Additional insecticides are expected to be classified before the 1978 planting season. Your county extension adviser will have additional information on insecticide restrictions. **An asterisk(*) is used throughout this circular to indicate insecticides classified for "restricted" use by the EPA.**

The chemical names used in this circular may be unfamiliar to you. These names are the common coined chemical names and as such are not capitalized (for example, terbufos). Trade names are capitalized (for example, Counter). In the table of limitations, the trade names are listed first, and the common name is in parentheses following the trade name. In the tables of suggestions, only the trade name is used if there is one. In case of questions, refer to the following list or to the table of limitations:

Trade name	*Common name*	*Classification*
Counter	terbufos	unclassified
Cygon	dimethoate	unclassified
Dasanit	fensulfothion	unclassified
diazinon	diazinon	unclassified
Dibrom	naled	unclassified
Di-Syston	disulfoton	unclassified
Dyfonate	fonofos	unclassified
Dylox	trichlorfon	unclassified
*ethyl parathion	parathion	restricted
Furadan	carbofuran	unclassified
*Guthion	azinphosmethyl	restricted
Imidan	phosmet	unclassified
*Lannate	methomyl	restricted[1]
Lorsban	chlorpyrifos	unclassified
malathion	malathion	unclassified
Meta-Systox R	oxydemetonmethyl	unclassified
methoxychlor	methoxychlor	unclassified
*methyl parathion	methyl parathion	restricted
Mocap	ethoprop	unclassified

[1] All formulations except water-soluble packages are restricted.

UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN — COLLEGE OF AGRICULTURE — COOPERATIVE EXTENSION SERVICE
In cooperation with ILLINOIS NATURAL HISTORY SURVEY — CIRCULAR 899 — Urbana, Illinois, December, 1977

Trade name	*Common name*	*Classification*
*Penncap-M	methyl parathion (microencapsulated)	restricted
Sevin	carbaryl	unclassified
Supracide	methadathion	unclassified
*Systox	demeton	restricted
Thimet	phorate	unclassified
toxaphene	toxaphene	unclassified
Trithion	carbophenothion	unclassified

(Consider all grain fumigants as restricted-use insecticides.)

Pesticide Safety

Certain precautionary steps should be taken when handling insecticides. Some of the insecticides suggested in the publication can be poisonous to the applicator. The farmer is expected to protect himself, his workers, and his family from needless exposure.

When using insecticides, apply all the scientific knowledge available to insure that there will be no illegal residue on the marketed crop. Such knowledge is condensed on the label. READ THE LABEL CAREFULLY AND FOLLOW THE INSTRUCTIONS. But the label should be recent and not from a container several years old. Do not exceed maximum rates suggested; observe the interval between application and harvest; and apply only to crops for which use has been approved. Make a record of the product used, the trade name, the percentage content of the insecticide, dilution, rate of application per acre, and the date or dates of application.

Always handle insecticides with respect. The persons most likely to suffer ill effects from insecticides are the applicator and his family. Accidents and careless, needless overexposure can be avoided. Here are a few rules that if followed will prevent most insecticide accidents:

1. Wear rubber gloves when handling insecticide concentrates.
2. Do not smoke while handling or using insecticides.
3. Keep your face turned to one side when opening, pouring from, or emptying insecticide containers.
4. Leave unused insecticides in their original containers with the labels on them.
5. Store insecticides out of reach of children, irresponsible persons, or animals; store preferably in a locked building. Do not store near livestock feeds. Better yet, buy no more pesticide than you will use. This eliminates a pesticide storage and disposal problem.
6. Wash out and bury, burn, or haul to the refuse dump all empty insecticide containers.
7. Do not put the water-supply hose directly into the spray tank.
8. Do not blow out clogged nozzles or spray lines with your mouth.
9. Wash with soap and water exposed parts of body and clothes contaminated with insecticides.
10. Do not leave puddles of spray on impervious surfaces.
11. Do not apply to fish-bearing or other water supplies.
12. Do not apply insecticides, except in an emergency, to areas with abundant wildlife.
13. Do not apply insecticides near dug wells or cisterns.
14. Do not spray or dust when weather conditions favor drift.
15. Observe all precautions listed on the label.
16. To avoid bee kill, apply insecticides after bee activity has been completed for the day; use the least toxic materials. *Warn beekeepers that you are applying insecticides.*

Policy Statement

Suggestions for the use of insecticides are based on available data. Soil texture, soil pH, rainfall, slope of the field, wind velocity at planting, and other unpredictable factors affect the efficiency. Please report control failures and the circumstances associated with such failures to us.

Requested label clearances for a few uses of some insecticides, carriers, and solvents are uncertain for 1978, since many requests have not yet been officially cleared. Anticipating needed changes in labeling, we began modifying these suggested uses a few years ago. We have attempted to anticipate any further label changes in 1978, but an occasional use may still be canceled. Be sure to check with your county extension adviser if you are in doubt about the insecticide you plan to use. We will make announcements of label changes through the news media to keep you up to date.

Suggestions for Insect Control in 1978

Predicting Need for Soil Insecticides on Corn

The type of crop rotation influences to a great extent whether a soil-insect problem will occur and the kind. Following are some guidelines for predicting soil-insect problems in corn and determining the need for using a soil insecticide at planting time. Exceptions can be expected occasionally since soil-insect problems are influenced by a variety of conditions unrelated to crop rotation — weather, soil type, planting date, hybrid, tillage, natural enemies, and others. Knowledge of soil-insect damage in a particular field in previous years is also helpful, since infestations tend to occur in the same fields and in the same area.

Corn After Soybeans

The potential for soil-insect problems in corn following soybeans is generally low. Soil insecticides are rarely necessary. In most fields of corn after soybeans, a diazinon planter-box seed treatment will be adequate to protect against attack by seed-corn beetles and seed-corn maggots. There are a few exceptions. *Corn rootworms* may occasionally be a problem when beetles deposit their eggs in soybean fields that contain volunteer corn, which when planted to corn the following year may have economic damage. Rootworm beetles will feed on the foliage of soybean plants, and they are especially attracted into soybean fields that are weedy or contain volunteer corn. Good weed control will reduce the attractiveness of soybean fields to rootworm beetles. Clean fields of soybeans will permit soybean-corn rotations with noneconomic damage from corn rootworms. *Black cutworms* may be a problem in corn where excess soybean plant debris remains on the soil surface. *White grubs* are an occasional problem in east-central Illinois in corn after soybeans.

Corn After Corn

The potential for rootworm damage is moderate to severe in the northern two-thirds of Illinois, and a rootworm insecticide may be needed in fields of continuous corn. Wireworms are occasionally a problem in southern areas. See discussion under rootworms.

Corn After Grass Sod

Wireworms and white grubs are potential problems. Apply a soil insecticide at planting time.

Corn After Clover and Alfalfa

Grape colaspis, grubs, wireworms, and cutworms are potential problems. Rootworms may be a problem in northern Illinois in corn following clover or alfalfa. Apply a soil insecticide at planting time.

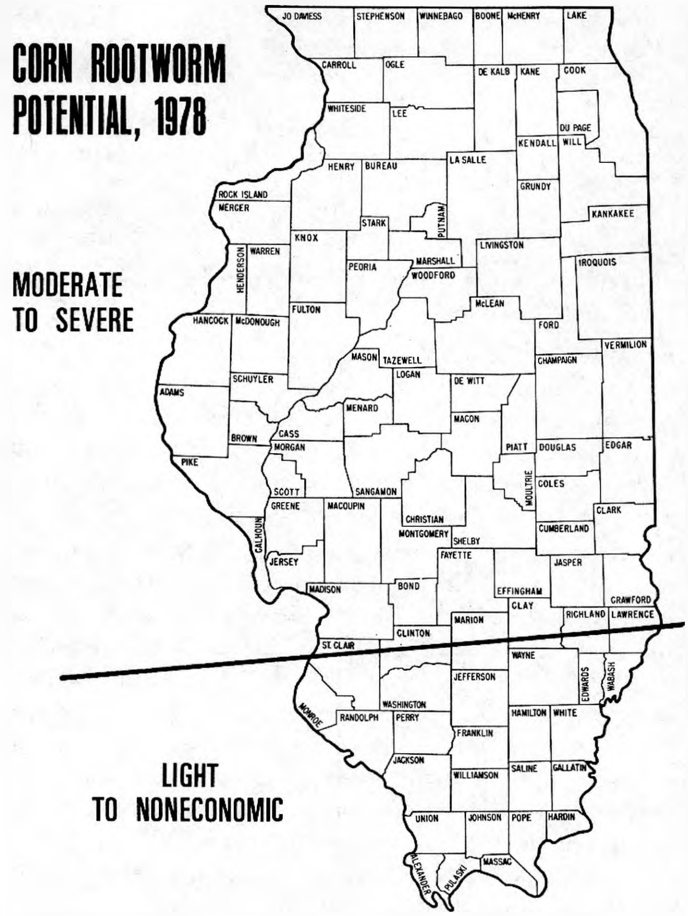
Corn After Small Grain

There is a slight potential for damage by wireworms, seed-corn beetles, and seed-corn maggots. In most instances, a diazinon planter-box seed treatment will be adequate. If wireworms are present, use a soil insecticide at planting.

Corn Rootworms

Rootworm Situation, 1978. Moderate to severe damage by western and northern corn rootworm larvae is expected in many fields of corn that follow corn in the area north of a line from Belleville to Lawrenceville (see map). The potential for rootworm damage south of this line is low. These predictions are based on a survey of rootworm beetle populations taken in late July, 1977.

Western and northern corn rootworm beetle populations were very high in the northern two-thirds of Illinois in 1977. Corn growers in the potential problem areas should base the need for using a soil insecticide on the abundance of rootworm beetles last summer. If they averaged one or more per corn plant during late July and August, 1977, or if lodging or elbowing occurred during



that time, the need for using a rootworm soil insecticide is high if the field is replanted to corn in 1978.

Rootworm Control by Cultural Practices. Here are some suggestions to aid in control.

1. Crop Rotation. This is the most effective method of preventing corn rootworm larval damage and should be given serious consideration by growers in 1978. It greatly reduces the number of egg-laying beetles on each farm. If feasible, do not grow corn two years in succession in the same field.

Farmers have been concerned about the number of corn rootworm beetles observed in soybean fields during 1977. All research to date indicates that corn following soybeans is unlikely to have a rootworm problem, and consequently would not need to be treated with a soil insecticide. An exception might be when corn is planted after soybeans and there was an extensive infestation of volunteer corn or weeds in the soybeans during August. Corn following alfalfa may benefit from treatment since rootworm beetles occasionally deposit their eggs in alfalfa fields during the bloom stage in August.

Fields of corn planted in late May or June, 1977, may have severe rootworm damage if planted to corn in 1978. Late-planted fields of corn very likely attracted high numbers of rootworm beetles from adjacent fields during August, 1977, seeking pollen and silks to feed upon. They will lay millions of eggs in these late-planted fields of corn. Planting these fields to a crop other than corn in 1978 will contribute toward reducing the overall rootworm population. Any field with 5 or more beetles per plant should be planted to another crop during 1978.

The larvae hatching from rootworm eggs cannot survive on the roots of broadleaf weeds or broadleaf crops (soybeans, small grains, alfalfa, or sorghum). Thus when a crop other than corn is planted in a field whose soil contains millions of rootworm eggs, literally millions of larvae will perish and not emerge as egg-laying beetles.

2. Planting Date and Variety. Plant last those fields that had high populations of rootworm beetles last July and August. Since egg-hatch commences in late May and June, soil insecticides applied in May will be more effective than those applied earlier because they won't have as much time to break down. Plant fields of corn after soybeans before planting fields of corn after corn.

Select a variety that has good standability and root-regeneration capability. No varieties are resistant to corn rootworm larvae, but some have more potential for root regeneration than others.

Rootworm Control With Insecticides. The soil insecticides suggested will give 50 to 70 percent control of corn rootworm larvae. This is adequate to prevent economic larval damage in most fields. In some heavily infested fields, there may be enough surviving larvae to cause economic root damage.

Larvae that are not controlled by the insecticides will emerge as beetles. High beetle numbers in fields last summer may leave the impression that rootworm control was poor, but if plants were standing and well rooted, control was probably acceptable even if populations were high.

Following are suggestions for rootworm control using insecticides:

1. Planting-Time Treatments. Apply Counter, Dyfonate, Furadan, Lorsban, Mocap, or Thimet in a 7-inch band ahead of the press wheel at the recommended rate (see table). Planting-time treatments applied in early April may give marginal control. Consider a late-May cultivator application in these fields, rather than a planting-time treatment.

If a soil insecticide gave good results in 1977, it will probably give adequate control in 1978. Exceptions have occurred when a particular insecticide has been used for several consecutive years in the same field. If an insecticide gave poor control last year, switch to another in 1978.

Research conducted in 1976-77 indicates that switching from a carbamate (Furadan) to an organic phosphate (Counter, Dyfonate, Lorsban, Mocap, or Thimet) may be desirable, particularly if Furadan has been used for several consecutive years in the problem field. In fields with a history of Furadan use, rootworm control with Furadan was marginal in 5 of 17 tests in 1976-77. In fields with a history of two or more years of organic phosphate soil insecticide use, rootworm control with a carbamate (Furadan) was equal to or slightly better than control with the organic phosphates in 11 of 11 tests.

Consequently, if control with Furadan was marginal or poor in 1977, switch to an organic phosphate (Counter, Dyfonate, Lorsban, Mocap, or Thimet) in 1978. In fields where Furadan failures have occurred, it may be advisable to wait longer than one year before using it again. If control with an organic phosphate was poor last year, switch to a carbamate (Furadan).

A word of caution about rotating classes of soil insecticides. In a few instances last year rotation of soil insecticides did not give good results. The performance of an insecticide that gives only fair control of rootworms will not be improved by rotation with other insecticides. Performance might be enhanced under favorable weather conditions or with light infestations.

The theory of rotating classes of rootworm soil insecticides, while basically sound, may be only a short-term solution to a long-term problem. Whenever insecticides, regardless of type, are used continuously and extensively over a large area, insect resistance to insecticides is likely to occur.

Soil Insecticides Suggested for Corn Rootworm Control at Planting, 1978

Insecticide	Class	Ounces of product per 1,000 ft. of row	Pounds of product needed per acre			
			40″ rows	38″ rows	36″ rows	30″ rows
Counter 15G	organic phosphate	8	6.7	7.0	7.4	8.7
Dyfonate 20G	organic phosphate	6	5.0	5.3	5.6	6.7
Furadan 10G	carbamate	12	10.0	10.5	11.1	13.3
Lorsban 15G	organic phosphate	8	6.7	7.0	7.4	8.7
Mocap 10G	organic phosphate	12	10.0	10.5	11.1	13.3
Thimet 15G	organic phosphate	8	6.7	7.0	7.4	8.7

During 1977, rootworm control research was conducted at 16 sites with economic infestations. Counter was satisfactory in 15 of 16 tests; Furadan in 14 of 16; Mocap in 14 of 16; Dyfonate in 13 of 16; Thimet in 13 of 16; and Lorsban in 10 of 16. Control in these tests was considered marginal for a treatment if enough brace roots were damaged by larvae to cause yield losses. These tests do not necessarily indicate similar results in 1978, but they are the best guide available.

Liquid formulations of Furadan 4F or Dyfonate 4E may be mixed with water and applied as a spray in a 7-inch band ahead of the press wheel or mixed with liquid fertilizer and applied with a split-boot applicator. Some farmers experienced compatibility or crop injury problems when using liquid insecticide-fertilizer planting-time treatments in 1977. The liquid insecticide *must* be compatible with the liquid fertilizer. A test should be conducted to make certain the mixture is physically compatible before planting. Maintain agitation in the tank after mixing and during application. *Use caution when handling liquid formulations. They are more toxic than granular formulations.* Broadcast applications of liquid and granular insecticides are not cleared for rootworm control.

2. Cultivator Treatments. The best time to apply a basal treatment of a soil insecticide by cultivator is in late May, near the time of egg-hatch. Such a treatment may be more effective than planting-time treatments in early April. Apply granular Dyfonate, Furadan, Mocap, or Thimet in a band at base of plants just ahead of the cultivator shovels and cover the granules with soil.

Cultivator applications of rootworm soil insecticides have some limitations. If rainfall is low for 3 or 4 weeks following the cultivator treatment, the insecticide granules will remain on the soil surface rather than moving down to where the larvae are feeding and control will be marginal. In the case of excess rainfall, it may not be possible to apply the cultivator application at the desired time.

3. Control of Rootworm Beetles. We do not suggest the use of insecticides to control rootworm beetles as a means of reducing or eliminating next year's larval infestations. Research thus far indicates this method of control to be variable. In general, the soil insecticide alone has been as effective as beetle control in late July or early August plus a soil treatment the following spring. At present, we suggest the use of aerial applications of insecticides only to control rootworm beetles where pollination damage may occur due to silk clipping.

Reasons for High Rootworm Beetle Populations in 1977. For the past three years, rootworm beetle numbers have been increasing in Illinois and are now at an all-time high. Climatic conditions favorable to the rootworm are probably the major factors responsible for the increase. Heavy rains immediately following planting hasten the decomposition of the soil insecticides and reduce control. Lack of rainfall may prevent the activation and movement of the soil insecticide from the soil surface to the area where rootworm larvae are feeding.

An increase in acreage of continuous corn, early planting, and low insecticide rates also contribute to increasing rootworm populations. Soil insecticides applied at planting in early to mid-April lose some of their potency by the time rootworm eggs are hatching in late May and June. Late-hatching larvae are not controlled, resulting in high survival and ultimately high beetle numbers. Insecticides applied at less than the labeled rate will result in poor or marginal control.

Use Scouting To Determine Rootworm Potential. The presence or absence of rootworm beetles in a cornfield is an excellent indicator of future rootworm problems. Corn growers can determine the potential for rootworm damage in 1979 by counting western and northern corn rootworm beetles between July 25 and August 25, 1978 in this way:

1. Count beetles in only those fields to be replanted to corn in 1979.

2. Make two and preferably three counts for western and northern corn rootworm beetles at 7- to 10-day intervals between July 25 and August 25 in each field.

3. If you enter a field and discover a "fog" of beetles, do not bother with the detailed counts.

4. Count the total number of western and northern corn rootworm beetles on 50 plants each time. Examine 10 plants selected at random in five areas of the field. It will take about 45 minutes to make your counts in a 40-acre field.

5. Move quietly as you approach a plant in order not to disturb the beetles. Count the beetles on the entire plant. This includes the ear tip, tassel, leaf surface, and behind the leaf axils. Pull the leaves away from the stalk and look in the leaf axils.

6. For the ear-tip count, grasp the ear tip so the silks are enclosed in the palm of the hand, and squeeze before any of the beetles escape. Cut off the ear tip with a knife, cutting only the silks. Open your hand slowly and count the beetles that come out of the silks for each of the 50 plants.

7. Record in a small notebook the number of beetles you find per plant.

If the average is more than one-half beetle per plant for any sampling date, plan to apply a rootworm insecticide in 1979. If a field averages less than one-half beetle per plant for all the counts, it can be planted to corn in 1979 without a soil insecticide treatment.

Rootworm Life Cycle. Western and northern corn rootworm beetles deposit their eggs in the soil at the base of the corn plants or between the rows during August and September. The eggs overwinter in the soil and commence hatching in late May. Egg-hatch usually takes place over a period of three to five weeks. Consequently, in July and August all stages of the corn rootworm — egg, larva, pupa, and adult — may be found. The rootworm larvae feed on the roots of the corn plants during June, July, and August. When a larva is fully grown (½ inch), it will build a cavity in the soil and go into the pupal, or resting, stage. After 5 to 10 days, the beetle will emerge from the soil. The development from egg hatch to adult emergence will take 27 to 40 days. Under field conditions and after mating, 14 days or more will elapse before the females commence egg laying. Rootworm beetles may deposit up to 1,000 eggs; an average of 500 per female is probably common. Most egg laying in Illinois occurs after August 1, and a high percentage of the eggs are deposited after August 10.

Black Cutworm Control

Early detection of leaf feeding or cutting by cutworms is vital for effective control. When corn plants are beginning to emerge, check fields for signs of leaf feeding, cutting, wilting, or missing plants. Small cutworm larvae (less than ½ inch) feed on the leaves and do not begin cutting plants until they are about half grown. If you find 3 percent or more of the plants being cut and 2 or more half-grown cutworms per 100 plants, a control measure is needed. Apply a Sevin pelletized bait or sprays of Sevin or Dylox at the first sign of cutworm damage. The pelletized bait should be broadcast on the surface of the soil and not incorporated. The sprays should be banded over the row.

Planting-time treatments of Mocap 10G and Lorsban 15G have received label registration by the Environmental Protection Agency. The label for Lorsban 15G states that it "will control moderate to low infestations of cutworms." The label for Mocap 10G states that it will "aid in the control" of black cutworms.

Research indicates that a planting-time treatment of Mocap or Lorsban is relatively effective in controlling light to moderate infestations of cutworms, but control may be unsatisfactory with heavy infestations. Because of the uncertainty in predicting which fields will have light or moderate outbreaks of cutworms, we do not suggest Mocap or Lorsban as planting-time treatments in 1978. It is more feasible to apply control measures when cutworm outbreaks appear.

Planter-Box Seed Treatments

A diazinon planter-box seed treatment will protect against attack by seed-corn beetles and maggots during germination. Use a seed treatment in fields that don't receive a soil insecticide at planting or when Furadan, heptachlor, or chlordane is applied at planting. The diazinon planter-box seed treatment is not needed if Counter, Dyfonate, Lorsban, Mocap, or Thimet is applied at planting. NOTE: Some loss of the seed treater will occur in air planters. Excess dust from the seed treater may also interfere with the monitor in air planters.

No-Till Corn

Soil insecticides can be profitably applied to corn following grass sod, or in any rotation in which grasses and weeds are prevalent. In no-till corn research trials, Furadan has controlled armyworms, billbugs, and flea beetles and has suppressed common stalk borers, first-generation European corn borers, wireworms, and white grubs when applied at 2 pounds active ingredient per acre at planting time in the furrow or as a 7-inch band ahead of the press wheel. Lower rates of Furadan are less effective against this insect complex, but may give better results than other soil insecticides. Based on these data, growers with a no-till corn program may wish to apply Furadan at planting time.

On no-till corn following corn (except in the rootworm area), soybeans, or a small grain, it does not generally pay to apply a soil insecticide. However, a diazinon seed treatment should be used.

Thimet, Dyfonate, Counter, Mocap, and Furadan will give some control of wireworms and white grubs in no-till corn planted in grass sod.

Alfalfa Weevil

In 1978 we expect alfalfa weevils to cause moderate to severe damage to the first cutting of alfalfa in all areas of Illinois. Growers should inspect alfalfa fields closely during April and May for signs of weevil damage.

Pest Management

Insects and related pests play a major role in field crop production in Illinois. Although agronomic practices developed during the past century have reduced the importance of some insect pests, they have increased the importance of others. Agronomic practices such as certain tillage operations, destruction of crop residues, selection of resistant hybrids, adjustment of planting dates, rotation of crops, and so on, if used properly, still serve to help suppress insect populations. Where possible, these practices continue to be used to provide more balanced insect control.

Practical applications of many insect-control techniques continue to be thoroughly investigated. Such control methods as insect sterilization, insect growth regulators, release of insect parasites and predators, attractants for insect baits and traps, propagation and dissemination of insect disease organisms, as well as the use of insecticides, are being pursued. Despite the most optimistic reports, however, it is readily apparent that insecticides will be an important part of pest management for many years to come.

FIELD CORN

Insect	Time of attack	Insecticide[1]	Lb. active ingredient per acre	Placement	Timing of application (See table of limitations, page 11)
Corn rootworm	June-August	Counter Dyfonate Furadan Lorsban Mocap Thimet	1[2] 1[2] 1[2] 1[2] 1[2] 1[2]	7-inch band	Apply ahead of planter press wheel. See discussion on page 4. Basal treatments during cultivation with Furadan, Dyfonate, Thimet, or Mocap are effective in late May or early June.
Seed-corn beetle	At germination	diazinon	1½ oz. per bu. of seed	On seed	Or as a band treatment, use Dyfonate or Thimet.
Seed-corn maggot	At germination	diazinon	1½ oz. per bu. of seed	On seed	Or apply Counter in the furrow or band treatments of Dyfonate.
Wireworm	May-June	Counter Dyfonate Furadan Mocap Thimet	1[2] 4 2[2] 1[2] 1[2]	Furrow Broadcast Furrow 7-inch band 7-inch band	Counter and Furadan should be applied in the seed furrow. Except for Dyfonate, apply all others as a 7-inch band ahead of the press wheel. If infestations are severe, control may not be satisfactory. Counter and Thimet are labeled for the reduction of wireworms.
White grub Grape colaspis	May-October May-June	The soil insecticides suggested for wireworms will give partial control of white grubs and grape colaspis. Furadan and Counter should be applied in the seed furrow and the other insecticides in a 7-inch band ahead of the press wheel. However, they are not labeled for these pests.			
Sod webworm	May-June	toxaphene	2	At base of plant	At time of initial attack.
Cutworms	May-June	Sevin bait	1-2	Broadcast	When feeding starts. Repeat if needed.
		Sevin plus molasses or Tractum	2	Direct at base of plant	Same as above. Use 1 quart of molasses per acre. Apply in the spray mix.
		Dylox spray	1	At base of plant	When feeding starts.
Billbug	May-June	toxaphene	2	At base of plant	Apply sprays as needed.
Garden symphylan	May-July	Dyfonate	2	Broadcast	Before planting, lightly incorporate.
Grasshopper	June-September	Sevin toxaphene diazinon malathion	1 2 ½ 1	Over row as spray	As needed. For ensilage corn use Sevin, diazinon, or malathion.
Flea beetle	May-June	Sevin diazinon toxaphene	1 ½ 2	Over row as spray	When damage becomes apparent on small corn.
Armyworm	May-August	Sevin malathion toxaphene Dylox *Lannate[3]	1½ 1 2½ 1 ½	Over row as spray	At first migration or when leaves below ear level are consumed and worms are eating leaves above ear level.
Fall armyworm	July-September	Sevin diazinon Dylox *Lannate[3]	1½ 1 1 ½	In whorls	Granules preferred when worms deep in whorl. If worms are small and out on leaves, sprays are effective. When silking, see suggestions for corn earworm.
Chinch bug	June-August	toxaphene	2	Spray at base of plant	At start of migration.
Thrips	June	malathion	1	On foliage as spray	When severe wilting and discoloration are noticed.
Japanese beetle	July-August	Sevin	1	Over plant	During the silking period to protect pollination.
Mites	July-August	Di-Syston granules Thimet granules Meta-Systox R Trithion	1 1 ½ 1	Into whorl Over plant	When leaves below ear are being killed and infestation is increasing.
Corn leaf aphid	July-August	Thimet granules	1	In whorl	Just before tasseling when aphids are appearing on individual plants. Not after tassel emerges. For seed fields only and not if field is to be detasseled by hand.
		malathion diazinon	1 1	Foliage spray	Apply during late whorl to early tassel when 50% of the plants have light to moderate infestations.

* Use restricted to certified applicators only.
[1] See page 11 for insecticide restrictions.
[2] Based on 40-inch row spacing. Increase rates for narrow rows.
[3] To be applied only by experienced operators or those wearing protective clothing.

FIELD CORN (continued)

Insect	Time of attack	Insecticide[1]	Lb. active ingredient per acre	Placement	Timing of application (See table of limitations, page 11)
Corn rootworm adults	Late July, early August	Sevin malathion diazinon	1 1 ½	Overall spray or directed towards silk	Before 50% of plants have silked, if there are more than 5 beetles per ear and if silk clipping is observed. Only to protect pollination.
Corn earworm	July-August	Sevin *Lannate[3]	1½ ½	Spray ear zone	Two applications at 3- to 5-day intervals, starting at 30-50% silk.
Corn borer, first generation	June-July	Sevin granules diazinon granules	1½ 1	On upper ⅓ of plant and into whorl	When tassel ratio is 30 to 50, and 50% or more plants show recent borer feeding in whorl.
Corn borer, second generation	Mid-August	Sevin granules diazinon granules Furadan granules	1½ 1 1	Over row	Apply at first hatch when there are 1 or more egg masses per plant.
Southwestern corn borer	August	Furadan granules	1	From ear upward	Direct granules into whorls. Apply when 25% of plants have egg masses or larvae on leaves. Early-planted corn usually escapes damage.

* Use restricted to certified applicators only.
[1] See page 11 for insecticide restrictions.
[3] To be applied by experienced operators or those wearing protective clothing.

STORED GRAIN (Corn, Wheat, and Oats)[1]

Insect	Time of attack	Insecticide and dilution	Dosage	Placement	Suggestions (See table of limitations, page 11)
Angoumois grain moth (earcorn)	April-October (southern ⅓ of Illinois only)	malathion 57% E.C., 3 oz. per gal. water	Apply to runoff	Spray surface and sides May 1 and August 1	Plant tight husk varieties. Store as shelled corn to avoid all but surface damage by angoumois moth.
Meal moths and surface infestations only[2]	April-October	dichlorvos 20% (DDVP, Vapona) plastic resin strip[3]	1 per 1,000 cu. ft. space above grain mass	Attach to ceiling or side wall	Clean and spray bin with 1.5% malathion to runoff before storage. Store only clean dry grain. Install June 1 or at storage. Replace in mid-August.
		pyrethrin 6% + piperonyl butoxide 60% E.C., 4½ oz. per gal. water	2 gal. per 1,000 sq. ft.	Spray grain surface, bin walls, and ceiling	Clean and spray bin with 1.5% malathion to runoff before storage. Store only clean dry grain. Apply June 1 or at storage and monthly thereafter during summer months
General					
Internal and external feeders Rice and granary weevils Flat grain beetle Saw-toothed grain beetle Rusty grain beetle Foreign grain beetle Cadelle beetle Flour beetle	April-October	malathion 57% E.C., 1 pt. per 3-5 gal. water[4]	3-5 gal. per 1,000 bu.	Spray uniformly as grain is binned	Clean and spray bin with 1.5% malathion to runoff before storage. Store only clean dry grain. Protect surface with dichlorvos resin strips or pyrethrin spray as recommended for meal moths.
		*liquid fumigant[5, 6]	3-5 gal. per 1,000 bu.	On surface; repeat if necessary	Clean and spray bin with 1.5% malathion to runoff before storage. Store only clean dry grain. Apply in late July and September in the southern half of Illinois; apply in mid-August in the northern half of Illinois. Protect surface with dichlorvos resin strips or pyrethrin spray as recommended for meal moths.
		*methyl bromide + *ethylene dibromide[6, 7]	As directed	On surface	
		*aluminum phosphide[6, 8]	180 tablets per 1,000 bu.	Tablets 2 feet apart	

* Use restricted to certified applicators only.
[1] Corn need not be treated if harvested after October 1 unless it is to be carried over the following summer. Wheat and oats should be treated if they are to be held for one month or more in storage after harvest.
[2] Remove webbing before treatment.
[3] Effective only in enclosed bins. Kills adult moths but not the eggs or larvae. Several weeks required to effectively control an existing infestation. Also cleared for use in bins of stored soybeans.
[4] Use only the grade of malathion labeled for use on stored grain. Apply after drying, as malathion vaporizes and is lost rapidly when grain is heat-dried.
[5] Some common liquid fumigants are: *carbon bisulfide + *carbon tetrachloride, *ethylene dichloride + *carbon tetrachloride, *ethylene dichloride + *ethylene dibromide + *carbon tetrachloride, etc.
[6] Use with extreme caution. Apply only under calm conditions and when grain temperature is 70° F. or above. Grain should be 8 inches below the lip of the bin and should be leveled before fumigating.
[7] Called the 73 mixture.
[8] Called *Phostoxin. Slow vaporization with a 3-day exposure period.

ALFALFA AND CLOVER

Insect	Time of attack	Insecticide[1]	Lb. active ingredient per acre	Placement	Timing of application[2] (See table of limitations, page 11)
Alfalfa weevil (Spring treatment)	March-June	Furadan[3,4] *Guthion[3] *methyl parathion[3] Supracide[3] *Lannate[3] malathion plus methoxychlor diazinon plus methoxychlor (Alfatox) Imidan *Penncap-M	¼ ½ ½ ½ 0.9 ¾ ¾ ½ 1 1 ½	On foliage	Refer to Circular 1136. Or, when 25% of the tips are being skeletonized and there are 3 or more larvae per stem, treat immediately; two treatments may be necessary on first cutting; regrowth following first cutting may need protection. By ground, use a minimum of 20 gal. of finished spray per acre (10 gal. on stubble) or 4 gal. by air. Do not apply during bloom. Instead cut and remove hay.
Clover leaf weevil	March-April	malathion	1	On foliage	When larvae are numerous and damage is noticeable, usually early to mid-April.
Spittlebug	Late April, early May	*Guthion[3] malathion	½ 1	On foliage	When bugs begin to hatch and tiny spittle masses are found in crowns of plants.
Aphid	April-May	Cygon or De-Fend diazinon malathion	½ ½ 1	On foliage	When aphids are becoming abundant and lady beetle larvae and adults, parasites, and disease are slight.
Leafhopper	Early July	Sevin diazinon Cygon or De-Fend Dylox Supracide[3]	1 ½ ½ ¾ ½	On foliage	When second-growth alfalfa is 4 to 6 inches high, or as needed.
Webworm	July-August	Sevin Dylox	1 1	On foliage	When first damage appears.
Variegated cutworm	April-June	Sevin bait Dylox *methyl parathion[3]	1½ 1 ½	On foliage	Cut, remove hay, and spray immediately
Armyworm	May-June, September	Sevin malathion Dylox	1½ 1¼ 1	On foliage	Only when grasses are abundant.
Grasshopper	June-September	Cygon or De-Fend Sevin diazinon malathion Furadan[3,4]	½ 1 ½ 1¼ ¼	On foliage	When grasshoppers are small and before damage is severe. When plants are blooming, do not apply Sevin or Cygon. Apply others only late in day.

* Use restricted to certified applicators only.
[1] See page 11 for insecticide restrictions.
[2] Before applying insecticides, be certain to clean all herbicides out of equipment. During pollination, apply very late in day or, if possible, avoid application during bloom.
[3] To be applied only by experienced operators or those wearing protective clothing.
[4] Only for pure stands of alfalfa. When using no more than ¼ pound per acre, allow 7 days between application and harvest. If you use ¼ to ½ pound per acre, allow 14 days to elapse between application and harvest.

SMALL GRAINS (Barley, Oats, Rye, Wheat)

Insect	Time of attack	Insecticide[1]	Lb. active ingredient per acre	Placement	Timing of application (See table of limitations, page 11)
Grasshopper	June-August	malathion toxaphene[2]	1 1½	On entire plant	Apply early while grasshoppers are small.
Armyworm	May-June	malathion toxaphene[2] Dylox	1¼ 1½ ¾	On foliage	When worms are still small and before damage is done. Do not use Dylox on rye.
Greenbug English grain aphid	May-June	Cygon *Systox[3] *parathion[3] *Penncap-M malathion	¼ ¼ ¼ ¼ 1	On foliage	When needed. Penncap-M is cleared for greenbug only. Use Cygon and Penncap-M on wheat only.
Hessian fly	Sept.-October; April-May	Di-Syston granules Thimet granules	1 1	In drill row	Use granules in a grass-seeder for susceptible varieties planted before fly-free date.

* Use restricted to certified applicators only.
[1] See page 11 for insecticide restrictions.
[2] For use on dairy farms only when alternate material is not available and when insect emergency exists. Do not apply as foliage sprays or dusts to or adjacent to dairy pasture, hay, or forage crops.
[3] To be applied only by experienced operators or those wearing protective clothing.

SOYBEANS

Insect	Time of attack	Insecticide[1]	Lb. active ingredient per acre	Placement	Timing of application (See table of limitations, page 11)
Bean leaf beetle	May-June, August	Sevin[2] *Guthion[4]	1 ½	On foliage	When leaf feeding becomes severe, but before plants killed or pods eaten.
Grasshopper	June-September	Sevin[2] malathion ULV toxaphene[3]	1 0.6 2½	On foliage	When migration from adjacent crops begins.
Green clover worm	August	Sevin[2] malathion *Lannate[4] Dipel	1 1 ¼ (see label)	On foliage	When damage occurs between blooming and pod fill. Usually requires 12 or more half-grown worms per foot of row and 15% defoliation to justify treatment.
Webworm	June-August	Sevin[2]	1		Usually requires 15% or more defoliation between blooming and pod-fill to justify treatment.
Mites	June-August	Trithion[4] Cygon	¾ ½	On foliage	As needed on field margins and entire field.
Stink bugs	July and August	Sevin[2] *Guthion[4]	1 ½	On foliage	As needed when bugs are numerous; 1 per yard of row may cause damage.
Thrips	June-August	Sevin[2]	¾	On foliage	As needed.
Mexican bean beetle	May-August	Sevin[2] malathion *Penncap-M	1 1½ ½	On foliage	If stand is being reduced on seedling beans or when defoliation exceeds 40% before bloom.

* Use restricted to certified applicators only.
[1] See page 11 for insecticide restrictions on soybeans.
[2] Sevin should not be used at more than 1 lb. per acre. Higher rates may damage plants.
[3] For use on dairy farms only when alternate material is not available and when insect emergency exists. Do not apply as foliage sprays or dusts to or adjacent to dairy pasture, hay, or forage crops.
[4] To be applied only by experienced operators or those wearing protective clothing.

GRAIN SORGHUM

Insect	Time of attack	Insecticide[1]	Lb. active ingredient per acre	Placement	Timing of application (See table of limitations, page 11)
Webworm	After heads form	Sevin	1½	On grain head	When 10 to 25 percent of the heads are infested with 5 or more larvae per head. Pest usually bad in wet seasons on late planted grain.
Corn earworm	After heads form	Sevin	1½	Direct at head or broadcast	When there is an average of 2 worms per head.
Midge	August-September	Cygon diazinon Sevin	¼ ¼ 1½	Direct at head	When 50% of heads have begun to bloom and there are 1 or more midge adults per head.
Corn leaf aphids	All season	Cygon malathion	¼ 0.9	Broadcast	Under drouth conditions when populations are heavy and damage is apparent.
Greenbug	June-July	*parathion[2] Cygon or De-Fend malathion	¼ ¼ 0.9	Broadcast	When greenbug damage is sufficient to cause death of more than 2 normal-sized leaves before the hard-dough stage.
Fall armyworm	July-August	Sevin	1½	Over row	When there is an average of 2 worms per head. Whorl feeding is seldom economic.

* Use restricted to certified applicators only.
[1] See page 11 for insecticide restrictions.
[2] To be applied only by experienced operators or those wearing protective clothing.

GRASS PASTURES AND NONCROP AREAS

Insect	Time of attack	Insecticide[1]	Lb. active ingredient per acre	Placement	Timing of application
Grasshoppers	June-July	Sevin 4-Oil malathion Sevin	1 1 1	On foliage	When nymphs are abundant and before migration into row crops. Treat while hoppers are small.

[1] See page 11 for insecticide restrictions.

LIMITATIONS IN DAYS BETWEEN APPLICATION OF THE INSECTICIDE AND HARVEST OF THE CROP AND OTHER RESTRICTIONS ON THE USE OF INSECTICIDES FOR FIELD CROP INSECT CONTROL

(Blanks in the table denote that the material is not suggested for that specific use in Illinois)

	Worker re-entry times[a] (hours)	Field corn			Sorghum	Forage crops			
		Seed and soil	Grain	Ensilage and stover		Alfalfa	Clover	Pasture	Seed
Counter (terbufos)	...	A	...	...	...	...	...	...	...
Cygon (dimethoate)	...	...	...	...	28	10,B	...	...	...
De-Fend (dimethoate)	...	...	...	...	28	10,B	...	...	...
diazinon	...	A	...	0	7	7	7	...	...
Di-Syston (disulfoton)	...	...	40	40	...	...	...	...	...
Dyfonate (fonofos)[b]	...	A	45	45	...	...	...	...	...
Dylox (trichlorfon)	...	...	C	C	...	0	0	0	...
*parathion[b]	48	...	...	...	12	...	...	...	...
Furadan (carbofuran)[b]	...	A	...	D	...	7,B	...	...	...
*Guthion (azinphosmethyl)[b]	24	...	...	...	...	16,B	16,B	...	...
Imidan (phosmet)	...	...	...	...	...	7,B	...	...	...
*Lannate (methomyl)[b]	...	...	3	3	...	7	...	...	...
Lorsban (chlorpyrifos)	...	A	...	...	...	...	...	...	...
malathion	...	...	5	5	7	0	0	0	0
Meta-Systox R (oxydemetonmethyl)	...	...	7	7	...	...	...	...	...
*methyl parathion[b]	48	...	...	...	...	15	15	15	15
Mocap (ethoprop)	...	A	...	...	...	...	...	...	...
*Penncap-M[c]	...	...	...	...	...	15	...	...	...
Sevin (carbaryl)	...	...	0	0	21	0	0	0	...
Supracide[b]	...	...	...	...	...	10,G	...	...	...
Thimet (phorate)	...	A	30,H	30,H	...	...	...	...	...
toxaphene	...	...	A	I	...	...	...	...	...
Trithion (carbophenothion)[b]	48	...	21,E	21,E	...	...	...	...	...

	Worker re-entry times[a] (hours)	Barley		Oats		Rye		Wheat		Soybeans	
		Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Forage
Cygon (dimethoate)	...	...	...	...	...	...	...	60	60	21	5
Dipel (*Bacillus thuringiensis*)	...	...	...	...	...	...	...	...	...	0	0
Di-Syston (disulfoton)	...	...	...	...	...	...	...	...	K	...	...
Dylox (trichlorfon)	...	21	21	21	21	...	...	21	21	...	...
*Guthion (azinphosmethyl)[b]	24	...	...	...	...	...	...	...	...	45	F
*Lannate (methomyl)[b]	...	...	...	...	...	...	...	...	...	14	7
malathion	...	7	7	7	7	7	7	7	7	3	3
*parathion[b]	48	15	15	15	15	...	...	15	15	...	...
*Penncap-M[c]	...	...	...	...	...	...	...	15	15	20N	20N
Sevin (carbaryl)	...	...	...	...	...	...	...	...	...	0	0
*Systox (demeton)[b]	48	45,L	...	45,L	...	...	...	45,L	...	...	...
Thimet (phorate)	...	...	...	...	...	...	...	...	M	...	...
toxaphene	...	A	J	A	J	A	J	A	J	21	J
Trithion (carbophenothion)[b]	48	...	...	...	...	...	...	...	...	7	J

* Use restricted to certified applicators only.

[a] Workers should be warned in advance of treatments. Workers may not enter fields treated with the insecticides without wearing protective clothing for the intervals indicated. They may not enter a field treated with other insecticides until the spray has dried or the dust has settled without wearing protective clothing. Protective clothing includes a hat, long-sleeved shirt, long-legged pants, and shoes and socks.

[b] Sprays to be applied only by experienced operators wearing proper protective clothing.

[c] Microencapsulated.

A. No specific restriction when used as recommended.

B. Apply only once per cutting, and do not apply during bloom.

C. Three applications may be made per season. Can be applied up to harvest.

D. Do not make a foliar application if Furadan 10 granules were applied at more than 10 pounds per acre at planting. Do not make more than two foliar applications per season.

E. Make no more than one application per season.

F. Do not graze or feed treated vines to livestock.

G. Make no more than one foliage and one stubble application per cutting.

H. Besides treatment at planting, one more application can be made at cultivation or over the corn later in the season.

I. Do not feed treated forage to dairy animals. Do not feed sprayed forage or granular-treated corn silage to livestock fattening for slaughter. Do not graze meat animals on granular-treated stover within 28 days of slaughter.

J. Do not graze or feed treated forage to dairy animals or animals being finished for slaughter.

K. Do not graze treated wheat within 30 days of treatment.

L. Apply no more than twice per season with at least 14 days between applications. Do not graze treated fields.

M. Do not graze treated wheat within 45 days of treatment.

N. Make no more than two applications per season.

References

This circular lists only suggested uses of insecticides for the control of many Illinois field crop pests, and is not designed to discuss other methods of control. Fact sheets discussing nonchemical control methods, descriptions of specific insects, and their life history and biology (designated by NHE numbers) can be obtained from offices of county extension advisers or by writing to Entomology Extension, 169 Natural Resources Building, Urbana, Illinois 61801. The following fact sheets about the insects mentioned in the circular are available:

Alfalfa Weevil — NHE-89
Angoumois Grain Moth — NHE-62
Aphid — NHE-14 and 19
Armyworm — NHE-21
Bean Leaf Beetle — NHE-67
Billbug — NHE-37
Chinch Bug — NHE-35
Clover Leaf Weevil — NHE-12
Clover Root Curculio — NHE-71
Corn Earworm — NHE-33
Corn Leaf Aphid — NHE-29
Corn Rootworm — NHE-26
Cutworm — NHE-38
Fall Armyworm — NHE-34
Flea Beetle — NHE-36
Garden Webworm — NHE-42
Grape Colaspis — NHE-25
Grasshopper — NHE-74
Green Clover Worm — NHE-75
Internal and External Feeders — NHE-64 and 65
Leafhopper — NHE-22
Meal Moths — NHE-63
Sod Webworms — NHE-42
Spittlebug — NHE-13
Sweet Clover Weevil — NHE-15
Thrips — NHE-39
White Grub — NHE-23
Wireworm — NHE-43

The following circulars can be obtained from county extension advisers or by writing to the Office of Publications, College of Agriculture, Urbana, Illinois 61801:

Circular 898, Insect Pest Management Guide — Livestock and Livestock Barns

Circular 900, Insect Pest Management Guide — Home, Yard, and Garden

These suggestions are revised annually by entomologists of the College of Agriculture and the Illinois Natural History Survey.

1978 Insect Pest Management Guide

HOME, YARD, and GARDEN

Much has been said about the effects of pesticides, particularly insecticides, on the health and well-being of the American people. However, you are also aware that you are constantly faced with a horde of insects, intent upon destroying your property or making your life uncomfortable. Destruction of crop residues, varietal selection, hand-picking, fertilization, tree pruning, irrigation, screening, and other practices may reduce the numbers of insects with which you must contend. Occasionally you can even avoid or at least reduce the destruction by some pests without using an insecticide, but for most insects you must rely on an insecticide to provide the satisfactory management that you want.

By careful use of insecticides and other pest management tools, you can enjoy reasonable freedom from insects without endangering either yourself, your family, or your pets. You must recognize, however, that insecticides are designed to destroy one group of animals — insects — and can be harmful to other animals, including man himself, if used with disregard of normal safety precautions. It is up to each insecticide user to handle, apply, and store insecticides safely to reap their benefits without suffering from their dangers.

This publication lists certain insecticides to control insect pests of food, fabrics, structures, man and animals, lawns, shrubs, trees, flowers, and vegetables. We have tried to suggest only the safest materials. Many people prefer to employ the services of a professional exterminator or custom applicator rather than to become involved with selection and application of an insecticide.

The names used in these tables are the common coined chemical names, not the trade names, and as such may not be familiar to you. For instance, the common name for *Cygon* is *dimethoate.* If there is no coined chemical name, the trade name is used but is capitalized.

Requested label clearances for a few uses of some insecticides, carriers, and solvents are uncertain for 1978, since many requests have not yet been officially cleared. Consequently, labels may be cancelled and the product removed from the market at any time. Anticipating this, we took a conservative attitude a few years ago and began modifying these suggested uses. We have attempted to anticipate any further label changes in 1978, but there still may be an occasional use cancelled. Be sure to check with your local county extension adviser if you are not sure about the insecticide you plan to use. We will make announcements of label changes through the news media in an attempt to keep you up to date.

Insecticides are being classified for *general use* or *restricted use* by the U.S. Environmental Protection Agency. Only a few insecticides have been classified for restricted use at this time. There are no insecticides listed in this circular that have a restricted use classification. A person wishing to use an insecticide classified for restricted use must be certified as a private or commercial pesticide applicator by the State of Illinois. Contact your county extension adviser in agriculture for details on this program.

Suggestions for use of insecticides, effective from a practical standpoint, are based on available data. Many factors affect efficiency of control. Report details of control failures to us.

In using these tables always read the footnotes before using the insecticides. They list precautions and other pertinent information.

These suggestions are subject to change without notification during the year.

Leaflets describing the life history, habits, and damage of specific insects and nonchemical methods of control can be obtained from offices of county extension advisers or by writing to Entomology Extension, 169 Natural Resources Building, Urbana, Illinois 61801. These are indicated by an NHE number in the tables.

This circular was prepared by entomologists of the University of Illinois College of Agriculture and the Illinois Natural History Survey.

UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN COLLEGE OF AGRICULTURE COOPERATIVE EXTENSION SERVICE
In cooperation with ILLINOIS NATURAL HISTORY SURVEY CIRCULAR 900 Urbana, Illinois, December, 1977

VEGETABLE INSECTS

Insects	Crop	Insecticide	Suggestions
Aphids (NHE-47) Mites (NHE-58) Thrips	Most garden crops	malathion or diazinon	Apply on foliage to control the insects. Aphids and leafhoppers transmit plant diseases; early control is important. Mites web on the underside of leaves; apply insecticide to underside of leaves early before extensive webbing occurs.
Blister beetles (NHE-72) Cutworms (NHE-77) Flea beetles (NHE-36) Grasshoppers (NHE-74) Leafhoppers (NHE-22) Picnic beetles (NHE-40)	Most garden crops	carbaryl	For cutworms, attach collars of paper, aluminum foil, or metal at planting for small numbers of plants, or apply insecticide to base of plants at first sign of cutting. Control grasshoppers in garden borders when hoppers are small. For picnic beetles, pick and destroy overripe or damaged vegetables.
All cabbage worms (NHE-45)	Cabbage and related crops, salad crops, and leafy vegetables	*Bacillus thuringiensis*[1]	Presence of white butterflies signals start of infestation. Control worms when small. It is almost impossible to raise cole crops in Illinois without controlling these pests.
Hornworms (NHE-130)	Tomatoes	carbaryl *Bacillus thuringiensis*[1]	Handpicking usually provides satisfactory control.
Earworms (NHE-33)	Tomatoes and sweet corn	carbaryl	Apply to late-maturing tomatoes 3 to 4 times at 5- to 10-day intervals from small-fruit stage. Apply at fresh-silk stage to early and late corn every 2 days 4 to 5 times.
Colorado potato beetles	Eggplant, potatoes, tomatoes	carbaryl	Apply as needed. Insects usually present only in late May and June.
Potato leafhoppers (NHE-22)	Potatoes, beans	carbaryl or malathion	Apply 3 to 4 times at weekly intervals starting in late May or early June. Late potatoes and beans require additional treatments. Most serious pest of potatoes and beans in Illinois.
Bean leaf beetles (NHE-67)	Beans	carbaryl	Leaves are riddled in early plantings. Apply once or twice as needed.
Mexican bean beetle	Beans	carbaryl	Except for southern Illinois, only a pest of late beans. Apply insecticide to underside of leaves.
Cucumber beetles (NHE-46)	Vine crops	carbaryl	Apply as soon as beetles appear in spring. When blossoming begins, apply insecticide late in the day so as not to interfere with pollination by bees.
Squash vine borers	Squash	carbaryl	Make weekly applications to crowns and runners when plants begin to vine. Apply late in day.
Corn borer	Sweet corn	carbaryl	Apply 4 times every 3 days to whorl and ear zone of early corn when feeding appears on whorl leaves.
Soil insects (including grubs, wireworms, root maggots)	All crops	diazinon	Mix 6 fluid ounces of 25% diazinon emulsion in enough water to cover 1,000 sq. ft., usually 2 to 3 gallons. Rake into soil.

Days to Wait Between Application and Harvest

	Collards, kale, and other leafy crops	Beans	Lettuce	Cabbage and related crops	Sweet corn	Onions	Vine crops[2]	Tomatoes	Pumpkin	Eggplant	Peas	Potatoes
carbaryl	14	0	14	3	0	..	0	0	0	0	0	0
diazinon	..	7	..	7	2	..	7	3	..	..	0	..
malathion	7	1	14	7	5	3	1	1	3	3	3	0

Amount of Insecticide for Volume of Spray

	1 gal.	6 gal.	100 gal.	Commercial dust
carbaryl (Sevin) 50% W.P.	2 tbl.	¾ cup	2 lb.	5%
diazinon 25% E.C.	2 tsp.	4 tbl.	1 qt.	4%
malathion 50-57% E.C.	2 tsp.	4 tbl.	1 qt.	4%

E.C. = emulsion concentrate; W.P. = wettable powder. An emulsion concentrate is a chemical pesticide dissolved in a solvent to which an emulsifier has been added. It can then be mixed with water to the desired strength before being used.

[1] No time limitations. [2] Only apply insecticide late in the day after blossoms have closed to avoid bee kill.

FLOWER INSECTS

Insect	Insecticide[1]	Dosage	Suggestions
Ants, soil-nesting wasps, and sowbugs (NHE-17, 79, 93, 111) White grubs	diazinon 25% E.C.	1 cup per 1,000 sq. ft.	Drench into soil.
Aphids, mealybugs, spittlebugs, lacebugs, scales (NHE-7, 114)	malathion 50-57% E.C.	2 tsp. per gal. water	Spray foliage thoroughly. Repeat treatments may be needed.
Blister beetles (NHE-72)	carbaryl 50% W.P.	2 tbl. per gal. water	Spray foliage. Repeat treatments may be needed.
Cutworms (NHE-77)	diazinon 25% E.C. diazinon 2% granules	6 oz. per 2-3 gal. water 5 lb. per 1,000 sq. ft.	Spray 1,000 sq. ft. soil at base of plants. Do not spray on plant foliage. Small numbers of plants can be protected with collars of paper, aluminum foil, or metal.
Grasshoppers (NHE-74)	carbaryl 50% W.P. malathion 50-57% E.C.	2 tbl. per gal. water 2 tsp. per gal. water	Spray foliage and also adjacent grassy or weedy areas.
Iris borer	dimethoate (Cygon, DeFend) 23.4% E.C. or 25% W.P.	4 tsp. per gal. water	Apply when irises are in bloom, but not on blooms and make only one application. Add a small amount of liquid detergent to spray mix to improve coverage on leaves.
Leaf-feeding beetles	carbaryl 50% W.P.	2 tbl. per gal. water	Spray foliage. Repeat treatments if needed.
Leaf-feeding caterpillars	Same as for leaf-feeding beetles		
Plant bugs and leafhoppers	Same as for leaf-feeding beetles		
Slugs (NHE-84)	metaldehyde bait Mesurol 2% bait		Apply as a bait to soil. Remove old leaves, stalks, poles, boards, and other debris where slugs like to hide and lay eggs.
Spider mites (NHE-58)	dicofol 18.5% E.C.	2 tsp. per gal. water	Pay particular attention to underside of leaves when spraying. Apply 2 or 3 times at weekly intervals.
Springtails (NHE-70)	malathion 50-57% E.C. malathion 4% dust	2 tsp. per gal. water	Spray foliage and soil. Apply to soil at base of plants.
Stalk borers (NHE-24)	Same as for leaf-feeding beetles		Spray foliage thoroughly and frequently.
Thrips	Same as for leaf-feeding beetles		Spray foliage carefully.
White flies (NHE-136)	pyrethrin 0.1%	aerosol spray	Spray foliage thoroughly. Repeat in 5 days.

[1] Use only one insecticide from those listed. Do not use oil-base sprays on plants. Do not use malathion on African violets. Do not use carbaryl on Boston ivy. Do not use diazinon on ferns. Repeated use of carbaryl foliage sprays may cause mite or aphid infestations to increase and become damaging. Do not use insecticides during full bloom. Do not use dimethoate on chrysanthemums.
E.C. = emulsion concentrate; W.P. = wettable powder.

FOR YOUR PROTECTION

1. Store insecticides out of reach of children, irresponsible persons, or animals; store preferably in a locked cabinet.
2. If you use a bait around or in the home, place it after the children have retired and pick it up in the morning before they get up. Furthermore, place it out of their reach. At present we do not encourage use of baits for insect control.
3. Avoid breathing insecticide sprays and dusts over an extended period. This is particularly true in enclosed areas such as crawl spaces, closets, basements, and attics.
4. Wash with soap and water exposed parts of body and clothes contaminated with insecticide.
5. Wear rubber gloves when handling insecticide concentrates.
6. Do not smoke while handling or using insecticides.
7. Leave unused insecticides in their original containers with the labels on them and in locked cabinets.
8. Triple-rinse empty pesticide containers and wrap in several layers of paper and dispose of one at a time through the municipal solid waste disposal system.
9. Do not leave puddles of spray on impervious surfaces.
10. Do not apply insecticides to fish ponds.
11. Do not apply insecticides near dug wells or cisterns.
12. Observe all precautions listed on the label.

TREE AND SHRUB INSECTS

Insects	Insecticide[1]	Suggestions[2]
Aphids (NHE-7)	diazinon malathion	Spray foliage thoroughly with force. Repeat as needed.
Bagworms (NHE-6)	carbaryl malathion *Bacillus thuringiensis*	Spray foliage thoroughly. Apply June 15. Later sprays are less effective. For late spraying, use *Bacillus thuringiensis*.
Borers (NHE-8) Bronze birch	dimethoate	Spray trunk and limbs thoroughly in late May and early June. Repeat in 3 weeks. See leaf miner recommendations on insecticide label.
Ash Lilac Peach tree	chlorpyrifos	Spray trunk and limbs in mid-June and repeat 4 weeks later.
Cankerworms (NHE-95)	carbaryl malathion *Bacillus thuringiensis*	Spray foliage when feeding or worms are first noticed in spring.
Eastern tent caterpillars	Same as for cankerworms	Spray when nests are first noticed.
Elm leaf beetle (NHE-82)	carbaryl	Spray as soon as damage is noticed.
European pine shoot moths and Nantucket pine moth (NHE-83)	dimethoate	Spray ends of branches thoroughly in late June for European species and in mid-May for Nantucket species.
Fall webworms	acephate carbaryl diazinon malathion *Bacillus thuringiensis*	Spray when first webs appear; clip off and destroy infested branches or burn out webs.
Galls (NHE-80, 81) Elm cockscomb Hickory Maple bladder	diazinon malathion	Spray foliage thoroughly when buds are unfolding. Sprays after galls form on leaves are ineffective.
Hackberry blister	diazinon malathion	Spray foliage thoroughly in late May. Kills psyllids in galls. Sprays after galls form on leaves are ineffective.
Cooley spruce Eastern spruce	diazinon malathion	Apply in late September or October or early spring just before buds swell.
Green-striped mapleworms	Same as for cankerworms	Spray as soon as damage is noticed.
Leaf miners Boxwood Hawthorn Oak	diazinon malathion	Spray foliage thoroughly when miners first appear. Repeat treatment in 10 to 12 days.
Birch Holly	dimethoate	Repeat treatment in 3 weeks.
Mealybugs	malathion	Spray foliage thoroughly and with force. Repeat in two weeks.
Mimosa webworms (NHE-109)	acephate carbaryl malathion *Bacillus thuringiensis*	Spray foliage thoroughly when first nests appear (June, July). A repeat treatment may be needed.
Mites (NHE-58)	dicofol	Pay particular attention to underside of leaves. Apply 2 or 3 times at weekly intervals.
Oak kermes	malathion	Spray foliage thoroughly about July 1 to kill the crawlers.
Periodical cicadas (NHE-113)	carbaryl	Spray all branches thoroughly when adults appear. Repeat in 7 to 10 days.
Sawflies	Same as for fall webworms	Spray as soon as worms or damage is evident.
Scale (NHE-100, 114)	diazinon malathion	Spray foliage thoroughly in early April for *Fletcher* and *European elm scale;* in late May for *pine needle* and *sweet gum scale;* in early June for *scurfy, oystershell,* and *euonymous scale;* in early July for *cottony maple, Juniper,* and *dogwood scales;* in mid-July for *spruce bud scale;* and again in early August for *oystershell scale.*
Cottony maple Putnam San Jose Tulip tree	dormant oil diluted according to label	Apply when plants are still dormant in late winter. Do not use on evergreens. For tulip tree scale, a malathion spray in late September or in early spring is also effective.

[1] Use only one insecticide from those listed.
[2] Treatment dates are listed for central Illinois. In southern Illinois apply 2 weeks earlier and in northern Illinois 2 weeks later.

TREE AND SHRUB INSECTS (continued)

Insects	Insecticide[1]	Suggestions[2]
Sycamore lace bugs	acephate carbaryl malathion	Spray when nymphs appear, usually in late May.
Thrips	Same as for aphids	Mainly on privet. Spray foliage thoroughly.
Yellow-necked caterpillars	acephate carbaryl malathion	Spray foliage when worms are small.
Zimmerman pine moths	dimethoate	Spray in mid-August and again two weeks later.

[1] Use only one insecticide from those listed.
[2] Treatment dates are listed for central Illinois. In southern Illinois apply 2 weeks earlier and in northern Illinois 2 weeks later.

Amount of Insecticide Needed for Volume of Spray

	1 gal.	6 gal.	100 gal.		1 gal.	6 gal.	100 gal.
carbaryl (Sevin) 50% W.P.[1]	2 tbl.	¾ cup	2 lb.	dicofol (Kelthane) 18.5% E.C.	2 tsp.	4 tbl.	1 qt.
chlorpyrifos (Dursban) 2E.	2 tsp.	4 tbl.	1 qt.	dimethoate (Cygon, DeFend) 23.4% E.C., 25% W.P.[3]	2 tsp.	4 tbl.	1 qt.
diazinon 25% E.C.[2]	2 tsp.	4 tbl.	1 qt.				
malathion 50-57% E.C.[4]	2 tsp.	4 tbl.	1 qt.	acephate (Orthene) 15.6% E.C.[5]	4 tsp.	1 cup	2 qt.

[1] Do not use on Boston ivy. [2] Do not use on ferns or hibiscus. [3] Do not use on chrysanthemums. [4] Do not use on canaert red cedar. [5] Do not use on flowering crab, sugar maple, or redbud.
E.C. = emulsion concentrate; W.P. = wettable powder.

LAWN INSECTS

Insects	Insecticide[1]	Dosage per 1,000 sq. ft.[2]	Suggestions
White grubs Ants (NHE-111)	diazinon 25% E.C. 5% G.	1 cup 2½ lb.	Apply as spray or granules to small area and then water in thoroughly before treating another small area. Grub damage will usually occur in late August and in September.
Ants (NHE-111) Cicada killer and other soiling-nesting wasps (NHE-57, 79)	diazinon 25% E.C. 5% G.	¾ cup 2 lb.	Apply as spray or granules and water in thoroughly. For individual nests pour 1% diazinon in nest. Seal in with dirt.
Sod webworms (NHE-115)	carbaryl 50% W.P. 5% G. diazinon 25% E.C. 5% G. chlorpyrifos 2 E.C. 0.5% G. Aspon 13% E.C.	½ lb. 4 lb. ¾ cup 2 lb. 1½ fl. oz. 5 lb. 1½ cups	As sprays, use at least 2.5 gal. of water per 1,000 sq. ft. Do not water for 72 hours after treatment. As granules, apply from fertilizer spreader. Webworms usually damage lawns in late July and in August.
Millipedes and sowbugs (NHE-93)	carbaryl 50% W.P. diazinon 25% E.C.	½ lb. ¾ cup	Spray around home where millipedes or sowbugs are crawling. If numerous, treat entire lawn.
Armyworms Cutworms	carbaryl 50% W.P. 5% G. chlorpyrifos 2 E.C. 0.5% G.	2 oz. 1 lb. 1½ fl. oz. 5 lb.	Apply as sprays or granules. Use 5 to 10 gal. of water per 1,000 sq. ft.
Chinch bugs	chloropyrifos 2 E.C. Aspon 13% E.C.	1½ fl. oz. 2⅔ cups	Spray infested areas where chinch bugs are present.
Aphids	malathion 50-57% E.C.	1 tbl.	Spray grass thoroughly.
Chiggers	diazinon	1 tbl.	Spray grass thoroughly.
Slugs (NHE-84)	Mesurol 2% bait		Apply where slugs are numerous. Scatter in grass. For use only in flower gardens and shrubbery beds.

[1] Use only one insecticide from those listed.
[2] To determine lawn size in square feet, multiply length times width of lawn and subtract nonlawn areas including house, driveway, garden, etc. Do not allow people or pets on lawn until the spray has dried.
E.C. = emulsion concentrate; W.P. = wettable powder; G. = granules.

ANIMAL AND NUISANCE INSECTS

Insects	Insecticide[1]	Method of application	Suggestions
Ants (NHE-111) Crickets Spiders (NHE-116, 17) Centipedes (NHE-93)	diazinon 0.5% spray diazinon 0.5% R.T.U. propoxur 0.5% R.T.U. chlorpyrifos 0.5% R.T.U.	*Outdoors:* Use a water-base spray of diazinon. Spray on outside of foundation of house	To prevent insect migrations into house, spray completely around outside foundation wall and adjacent strip of soil. *Indoors:* Use R.T.U. oil-base sprays according to pesticide label. Apply to baseboards, cracks, and door thresholds.
Bed bugs	malathion 1% spray malathion 1% dust	Spray slats, springs, and bed frame thoroughly.	Apply a light dust to seams, tufts, and folds of mattresses. Use clean bedding.
Boxelder bugs (NHE-9)	diazinon 0.5% spray carbaryl 0.25% spray	*Outdoors:* Spray trunks of infested boxelder trees during late summer when bugs are present.	*Outdoors:* Spray the clusters of boxelder bugs on trunks of trees, foundation walls (diazinon only), under eaves, and other areas where they gather. Removal of seed-bearing boxelder trees is also helpful. *Indoors:* Remove with vacuum or broom.
Chiggers (NHE-127)	diazinon 1 oz. per 3 gal. of water per 125 sq. ft.	*Outdoors:* Treat lawns, roadsides, and areas not mowed.	For personal protection a repellent such as DEET will prevent attack. Take a warm soapy shower or bath immediately after returning from an infested area.
Wood ticks (NHE-56)	stirifos 4 oz. per 3 gal. of water malathion 2.5%	*Outdoors:* Treat lawns, fence rows, roadsides, and areas not regularly mowed. Do not spray animals.	For personal protection a repellent such as DEET will help prevent attack.
Clover mites (NHE-2)	dicofol 0.03% spray	Purchase E.C. and dilute with water. Spray outside of house from ground up to windows and adjacent 10 ft. of lawn.	Repeat spray in 7-10 days if necessary. Remove grass and weeds from 18-inch strip next to foundation. *Indoors:* Remove with vacuum, or spray with 0.1% R.T.U. pyrethrin in house.
Cluster flies (NHE-1)	dichlorvos 20% resin strip[2] pyrethrin 0.1% R.T.U.	1 strip per 1,000 cu. ft. in attic or room. Fog lightly in room.	Repeat spray with pyrethrin as needed. Seal cracks around windows, eaves, and siding to prevent entry.
Drain flies (NHE-91)	pyrethrin 0.1% R.T.U., or 20% dichlorvos resin strips[2]	Use fine mist or fog of pyrethrin or 1 resin strip per 1,000 cu. ft.	*Indoors:* Use chemicals only after solving sanitation problems. Clean out overflow drains, drain traps, and cellar drains. Pour boiling water or rubbing alcohol into overflow drain to eliminate maggots.
Elm leaf beetles (NHE-82)	pyrethrin 0.1% R.T.U. carbaryl 0.25% spray	*Indoors:* Use vacuum.	*Outdoors:* Spray with carbaryl on nearby Chinese elm trees for control of elm leaf beetle larvae and adults. Seal cracks around windows to prevent entry.
Fleas (NHE-107) Brown dog tick (NHE-56)	carbaryl 5% dust malathion 4% dust	Dust areas inside and outside the home where the pet rests. Dust pets directly as needed.	*Indoors:* For heavy infestations of ticks or fleas mist with 0.1% R.T.U. pyrethrin in infested rooms at frequent intervals. Vacuum rugs and upholstered furniture thoroughly. (Do not use carbaryl on kittens less than 4 weeks old.)
House flies (NHE-16) Gnats Midges Mosquitoes (NHE-94, 132) Punkies	*Outdoors:* malathion 1% spray	Purchase E.C. and dilute with water. Spray tall grass and around doorways, refuse containers, and other resting sites.	Dispose of refuse twice each week. Eliminate standing water in eave troughs, tires, toys, tin cans, children's swimming pools, etc. Use a repellent like DEET when entering mosquito-infested areas.
	Indoors: pyrethrin 0.1% R.T.U. space spray; or dichlorvos 20% resin strips[2]	Use fine mist or fog of pyrethrin or use one 20% dichlorvos resin strip per 1,000 cu. ft.	Use screening and keep repaired. Dichlorvos resin strips give good control in tight enclosed areas for about 3 months. Fly swatters are also effective.
Lice, human	malathion 1% dust carbaryl 5% dust	1 oz. per adult person	Dust lightly over body hair, and wash clothing and bedding. Repeat in 2 weeks if needed. Do not get in eyes.
Millipedes, sowbugs (NHE-93)	diazinon 0.5% spray	Spray outside foundation and at least 3 ft. of adjacent soil.	If abundant, treat entire lawn according to pesticide label. Remove debris from ground along foundation. *Indoors:* Collect with vacuum.

[1] Whenever possible purchase specially prepared ready-to-use forms of insecticides for indoor use. Use only one insecticide from those listed. When preparing a quantity of 1 gallon or more of a spray of a desired percentage, use the dilution table on page 8. You need to know only the formulation of the insecticide when using the dilution table.

[2] Do not use in pet shops or if tropical fish are present. Do not use in kitchens, restaurants, or areas where food is present. Do not use in nurseries or rooms where infants, ill, or aged persons are confined. Do not use in hospitals or medical clinics.

E.C. = emulsion concentrate; W.P. = wettable powder; R.T.U. = ready to use; O. = oil solution (usually in pressurized spray can).

ANIMAL AND NUISANCE INSECTS (continued)

Insects	Insecticide[1]	Method of application	Suggestions
Springtails (NHE-70)	diazinon 0.5% spray	*Outdoors:* Spray soil next to the house, especially grassy moist areas.	Eliminate low moist spots around the house. *Indoors:* Use vacuum. Allow soil to dry in potted plants or planter boxes.
Wasps (NHE-79) Hornets (NHE-17) Bees	carbaryl 5% dust; diazinon 5% G. dichlorvos 0.5% R.T.U. dichlorvos 20% resin strip[2]	Hanging dichlorvos resin strips in attic will help prevent infestations. For quick kill use dichlorvos 0.5%.	For nests below ground, apply diazinon according to label and seal opening with soil. Spray above-ground wasp and hornet nests with dichlorvos. For bees, treat nests in partitions with carbaryl. Drill holes through siding to inject insecticide, if necessary. Nests and honey should be removed and destroyed. Treat nests after dark.
Earwigs	diazinon 0.5% spray propoxur 0.5% R.T.U.	*Outdoors:* Use a water-base spray of diazinon. Spray on outside foundation of the house. Treat entire lawn according to pesticide label if pests are abundant.	To prevent migration into house, spray completely around outside foundation wall and adjacent strip of soil. *Indoors:* Use propoxur oil-base spray in R.T.U. cans. Apply to baseboards, cracks, and door thresholds.

FOOD, FABRIC, AND STRUCTURAL INSECTS

Insects	Insecticide[1]	Method of application	Suggestions
Carpenter ants (NHE-10)	diazinon 0.5% R.T.U. propoxur 0.5% R.T.U. chlordane 2% O. or 5% dust[3]	Spray or dust nest entrances and runways.	Use foundation spray as recommended for ants. Treat nests directly for best results.
Carpet beetles (NHE-87) Clothes moths (NHE-87)	diazinon 0.5% R.T.U.	Spray storage areas and infested places like the back and edge of carpeting, baseboards, beneath drawers, etc.	Prevent lint and dust from accumulating. Clean hot air registers and cold air shafts. Dry cleaning kills these pests. Store cleaned or washed woolens in insect-free chests and plastic bags.
Larder beetles	None		Remove source such as dead animal carcasses.
Cockroaches: German (NHE-3) Brown-banded (NHE-4) American (NHE-5) Oriental (NHE-5)	diazinon 0.5% R.T.U. propoxur 0.5% R.T.U. chlorpyrifos 0.5% R.T.U.	Spray runways and hiding places. Repeat treatments may be needed in 2 or 3 weeks.	Treat under sink, refrigerator, cabinets, on baseboards, etc. Complete treatment throughout home may be needed for successful control of brown-banded roach.
Pantry and cereal insects Saw-toothed grain beetles (NHE-11) Cigarette beetles	propoxur 0.5% R.T.U. pyrethrin 0.1% R.T.U.[4]	Spray inside of food cabinets very lightly and only after shelves are empty and cleaned.	Discard infested packages. Scrub or vacuum food cabinets and shelves. Force spray into cracks and crevices; allow to dry; cover shelves with clean, fresh paper. Do not contaminate food or utensils with insecticide.
Powder-post beetles (NHE-85)	chlordane 2% O.[3] Pentachlorophenol 5% O.	Paint, spray, or dip to saturate infested unfinished wood.	Pentachlorophenol is a wood preservative also, but it has a strong persistent odor. Follow label directions.
Silverfish (NHE-86)	diazinon 0.5% R.T.U. propoxur 0.5% R.T.U.	Spray runways, baseboards, closets, and places where pipes go through the walls.	Repeat treatments in 2 weeks if needed. Keep books and papers in dry places.
Termites (NHE-57)	chlordane 1% Purchase E.C. and dilute with water or oil	For soil injection along the building foundation and under footings, use 1 gal. per 2 cu. ft. of soil.	Remove termite mud tubes connecting wood to soil. Eliminate wood-to-soil contacts. Ventilate to keep unexcavated areas dry.

[1] Whenever possible purchase specially prepared ready-to-use forms of insecticides for indoor use. Use only one insecticide from those listed. When preparing a quantity of 1 gallon or more of a spray of a desired percentage, use the dilution table on page 8. You need to know only the formulation of the insecticide when using the dilution table.

[2] Do not use in pet shops or if tropical fish are present. Do not use in kitchens, restaurants, or areas where food is present. Do not use in nurseries or rooms where infants, ill, or aged persons are confined. Do not use in hospitals or medical clinics.

[3] While supplies last.

[4] Lasts for a few hours to a day or two.

E.C. = emulsion concentrate; W.P. = wettable powder; R.T.U. = ready to use; O. = oil solution (usually in pressurized spray can); G. = granules.

PESTICIDE DILUTION TABLE

HOW TO USE: When preparing a spray of a desired percentage you need to know only the formulation of the particular product (examples: Kelthane 18.5% wettable powder; Kelthane 18.5% emulsion concentrate). For instance, if you were preparing a 0.5% diazinon solution for spraying the foundation of the home, you would mix 5 tablespoons of diazinon 25% E.C. into each gallon of water. The formulations of insecticides in the table may be purchased from hardware stores, pest control establishments, lawn and garden centers, and other sources. For some jobs, such as spraying outdoors to control flies or mosquitoes, a gallon or more of properly diluted spray is required. To obtain the percent concentration suggested for controlling a particular insect, add the amount of pesticide suggested in the table to one gallon of water.

(For control of animal, nuisance, food, fabric, and structural insects. *Do not* use this table for vegetable, flower, tree, shrub, or lawn insects.)

Pesticide formulation	Amt. insecticide needed per gal. spray				
	Desired concentration				
	0.03%	0.25%	0.5%	1.0%	2.5%
carbaryl (Sevin) 50% W.P.	..	2 tbsp.	4 tbsp.	8 tbsp.	..
chlordane 45% E.C.	..	..	8 tsp.	5 tbsp.	..
chlordane 72% E.C.	..	..	4 tsp.	8 tsp.	..
diazinon (Spectracide) 25% E.C.	..	..	5 tbsp.	10 tbsp.	..
dicofol (Kelthane) 18.5% W.P.	2 tsp.	..	..	..	..
dicofol (Kelthane) 18.5% E.C.	1½ tsp.	..	..	..	..
Dursban 2E.	..	..	..	3 tbsp.	..
malathion 50-57% E.C.	..	..	7 tsp.	4½ tbsp.	10 tbsp.

(*tbsp. = tablespoon; tsp. = teaspoon*)

Conversion Table for Small Quantities

1 level tablespoon = 3 level teaspoons	1 pint = 2 cups
1 fluid ounce = 2 tablespoons	1 quart = 2 pints or 32 fluid ounces
1 cup = 8 fluid ounces or 16 tablespoons	1 gallon = 4 quarts or 128 fluid ounces

NAMES OF INSECTICIDES

Below is a list of the common names of insecticides used in the preceding tables, followed by the commercial trade name and the chemical name. Some products may be available under a variety of trade names not listed below. Be sure to read the label. The label on the container always lists these products by the common name or chemical name.

Common Name	Trade Name	Chemical Name
carbaryl	Sevin	1-naphthyl methylcarbamate
chlorpyrifos	Dursban	O, O-diethyl O-(3,5,6-trichloro-2-pyridl) phosphorothioate
DEET	Off, Kik	N, N-diethyl-m-toluamide
diazinon	Spectracide	O, O-diethyl O-(2-isopropyl-4-methyl-6-pyrimidyl) phosphorothioate
dichlorvos	Vapona, DDVP	2,2-dichlorovinyl dimethyl phosphate
dicofol	Kelthane	4,4′-dichloro-a-(tri = chloromethyl) benzhydrol
dimethoate	DeFend, Cygon	O, O-dimethyl S-(N-Methyl carbamoyl methyl) phosphorodithioate
ethyl hexanediol	6-12, Rutgers 612	2-ethyl-1, 3-hexanediol
malathion	Cythion	diethyl mercaptosuccinate, S-ester with O, O-dimethyl phosphorothioate
propoxur	Baygon	O-isopropoxyphenyl methyl carbamate
pyrethrin		principally from plant species *Chrysanthemum cinariaefolium*
stirifos	Rabon	2-chloro-1-(2,4,5,-trichlorophenyl) vinyl dimethyl phosphate

1978 INSECT PEST MANAGEMENT GUIDE FOR COMMERCIAL APPLICATORS FOR TREES, SHRUBS, AND TURFGRASS

Tree and Shrub Insects

Insect	Insecticide	Lb. of active ingredient per 100 gal. of water	Timing of application[a]
Aphids	malathion	1	When aphids are numerous.
	diazinon	1	
Ash borer	chlorpyrifos	1	Apply in early May and repeat 4 weeks later.
	endosulfan	1	
	acephate	1	
Bagworm	malathion	1	Spray foliage thoroughly about June 15 while worms are still small.
	carbaryl	2	
	chlorpyrifos	1/2	
	Bacillus thuringiensis	follow label directions	
	dimethoate	1/2	
	acephate	1	
Birch leaf miner	malathion	1	Spray foliage thoroughly when miners first appear. Repeat 10 to 12 days later.
	diazinon	1	
	Imidan	3/4	
Black vine weevil	endosulfan	1	Spray foliage thoroughly in mid-May when adults are on needles. Allow spray to runoff onto soil under shrubs.
Bronze birch borer	dimethoate	1/2	Spray bark of trunk and limbs in early June and repeat 3 weeks later.
Cankerworms	malathion	1	Spray when worms are still small as leaf buds are opening in spring.
	diazinon	1	
	carbaryl	2	
	Imidan	3/4	
	Bacillus thuringiensis	follow label directions	
Carpenterworm	———		No known control.
Cicada	carbaryl	2	Spray foliage when egglaying begins. Repeat every 5 days while adult cicadas are present.
Cooley spruce gall aphid	malathion	1	Apply in late September or in early spring just before buds swell.
	diazinon	1	
	endosulfan	1	
Cottony maple scale	malathion	1	Spray in July after crawlers have hatched and repeat 10 days later.
	diazinon	1	

[a]Treatment dates are listed for central Illinois. In southern Illinois apply 2 weeks earlier and in northern Illinois 2 weeks later.

Insect	Insecticide	Lb. of active ingredient per 100 gal. of water	Timing of application[a]
Cottony maple scale (continued)	superior oil	2 gallons	Apply in spring before leaf emergence. Do not use on Japanese or sugar maple.
Dogwood borer	endosulfan	1	Apply in mid-May and repeat 4 weeks later.
Eastern spruce gall aphid	malathion	1	Apply in late September or in early spring just before buds swell.
	diazinon	1	
	endosulfan	1	
	chlorpyrifos	1	
Eastern tent caterpillar	malathion	1	Spray areas of tree where nests first appear in early spring.
	diazinon	1	
	Bacillus thuringiensis	follow label directions	
	chlorpyrifos	1	
Elm bark beetles	methoxychlor	...	Contact Section of Applied Botany and Plant Pathology, Illinois Natural History Survey,. Urbana, Illinois 61801, for information on Dutch elm disease control.
Elm cockscomb gall	malathion	1	Usually no control is necessary.
Elm leaf beetle	carbaryl	2	
	malathion	1	
	diazinon	1	
Eriophyid mites	dicofol	1/2	Spray only when injury is observed. Usually control is not necessary.
Euonymous scale	dimethoate	1	Spray in early June. Make four applications 10 to 12 days apart.
	malathion	1	
	diazinon	1	
European elm scale	malathion	1	Apply in early spring when first leaves appear.
European pine sawfly	carbaryl	2	Spray when worms are present and feeding on the needles.
	malathion	1	
	diazinon	1	
European pine shoot moth	dimethoate	1/2	Spray ends of branches thoroughly in late March and early July.

[a]Treatment dates are listed for central Illinois. In southern Illinois apply 2 weeks earlier and in northern Illinois 2 weeks later.

Insect	Insecticide	Lb. of active ingredient per 100 gal. of water	Timing of application[a]
Fall webworm	acephate	1	Spray nests on webbed areas in trees in late summer.
	carbaryl	2	
	malathion	1	
	diazinon	1	
	Bacillus thuringiensis	follow label directions	
	chlorpyrifos	1	
Flat-headed apple tree borer	dimethoate	1/2	Spray in late May and repeat twice at 3-week intervals. Keep trees in vigorous growing condition. Wrap trunks of new set trees with paper or burlap.
Fletcher scale	malathion	1	Apply in early April and repeat in early July.
Forest tent caterpillar	carbaryl	2	Spray when caterpillars are present.
	malathion	1	
	diazinon	1	
Gouty oak gall	...	...	Prune out infested branches and destroy.
Hackberry psyllids	malathion	1	Apply in late May. This insect rarely damages trees.
	diazinon	1	
Hawthorn leaf miner	malathion	1	Treat in early May or when first sign of leaf-browning appears
	diazinon	1	
Hawthorn mealy bug	malathion	1	Apply when insects are numerous.
	diazinon	1	
	dimethoate	1/2	
Holly leaf miner	dimethoate	1/2	Spray foliage in late May or early June when leaf miners first appear.
Honey locust pod gall	...	...	No chemical control is necessary.
Lacebug	carbaryl	2	Spray when bugs are numerous.
	malathion	1	
Leaf crumpler	malathion	1	Spray in late May and again in late August.
	diazinon	1	
Leafhoppers	carbaryl	2	Spray when hoppers are numerous on foliage.
Lecanium scale	diazinon	1	Apply to infested trees in mid-June and repeat 2 weeks later.
	malathion	1	

[a]Treatment dates are listed for central Illinois. In southern Illinois apply 2 weeks earlier and in northern Illinois 2 weeks later.

Insect	Insecticide	Lb. of active ingredient per 100 gal. of water	Timing of application[a]
Lilac borer	endosulfan chlorpyrifos	1 1	Apply in mid-May and repeat 4 weeks later.
Locust borer	carbaryl	2	Apply in late August and again in mid-September.
Locust mite	dicofol	1/2	Apply in early spring just before leaves appear. Repeat spray 2 weeks later.
Magnolia scale	malathion diazinon	1 1	Treat in late September or early spring when buds are opening.
Maple bladder gall	dicofol	1/2	Chemical control usually is not necessary. If infestation has been severe, spray tree as leaf buds are opening in spring.
Mimosa webworm	acephate malathion diazinon *Bacillus thuringiensis* carbaryl chlorpyrifos	1 1 1 follow label directions 2 1	Spray in late June or when webs first appear. Repeat in August for second generation.
Mountain ash borer	chlorpyrifos endosulfan	1 1	Treat in early June and repeat 4 weeks later.
Nantucket pine moth	acephate dimethoate	1 1/2	Spray ends of branches in early May.
Oak kermes	malathion diazinon	1 1	Apply when crawlers appear on foliage in early July.
Obscure scale	superior oil	2 gallons	Apply in late October or in early spring just prior to leaf emergence.
Oystershell scale	malathion dimethoate	1 1/2	Apply in early June and repeat 10 to 12 days later. Repeat sprays again in early August in central and southern Illinois.
Peach tree borer	endosulfan chlorpyrifos	1 1	Spray thoroughly bark of trunk and limbs in mid-June and repeat 4 weeks later.
Periodical cicada	carbaryl	2	Spray when adults are laying eggs in June.
Pine bark aphid	malathion diazinon	1 1	Spray when aphids are present, usually in May and later.

[a]Treatment dates are listed for central Illinois. In southern Illinois apply 2 weeks earlier and in northern Illinois 2 weeks later.

Insect	Insecticide	Lb. of active ingredient per 100 gal. of water.	Timing of application[a]
Pine needle scale	acephate malathion diazinon chlorpyrifos	1 1 1 1	Apply spray in mid-May if trees are infested.
San Jose scale	superior oil	2 gallons	Apply to bark of trunk and limbs in spring prior to leaf emergence.
Spider mites	dicofol	1/2	Spray when mites are numerous. Especially serious on juniper.
Spittle bug			No chemical control is necessary.
Taxus mealy bug	acephate malathion diazinon	1 1 1	Spray foliage with force when insects are present. Repeat 2 weeks later.
Thrips	malathion acephate	1 1	Spray privet when thrips are numerous.
Tuliptree scale	superior oil malathion	2 gallons 1	Apply oil in late spring before leaves emerge. Apply malathion in mid-August.
Twig pruner			No known control.
White-marked tussock moth	malathion carbaryl diazinon	1 2 1	Treat when worms are present in June.
Yellow-necked caterpillar	malathion diazinon acephate	1 1 1	Spray foliage on which caterpillars are feeding, usually in late July.
Zimmerman pine moth	dimethoate	2	Spray bark and foliage in mid-August and again 2 weeks later.

[a]Treatment dates are listed for central Illinois. In southern Illinois apply 2 weeks earlier and in northern Illinois 2 weeks later.

Turfgrass Insects

Insects	Insecticide	Lb. of active ingredient per acre	Timing of application
Ants and soil-nesting wasps	diazinon spray	4	Apply when insects are present.
Aphids (greenbug)	malathion spray	1	Apply only when aphids are present.
	diazinon spray	1	
Armyworms and cutworms	carbaryl spray or granules	8	Treat when worms are present.
	trichlorfon spray or granules	5	
	diazinon spray or granules	4	
	chlorpyrifos spray or granules	1	
Chiggers	diazinon	1	Apply to grass area where chiggers have been a problem.
	malathion	1	
Chinch bugs	chlorpyrifos spray	1	Spray when bugs are numerous.
	trichlorfon spray	5	
	Aspon spray	8	
	diazinon	4	
Grubs, including true white, annual white, Japanese beetle, green June beetle	diazinon spray or granules	5	Treat damaged areas and where grubs are present in soil. Water-in very thoroughly.
	trichlorfon spray or granules	8	
Leafhoppers and grasshoppers	carbaryl spray	4	Treatment usually is not necessary unless hoppers are numerous.
Millipedes	carbaryl spray	8	Apply to turf where millipedes are migrating across area.
	diazinon spray	4	
Slugs	Mesurol bait		Apply by scattering in grass.
Sod webworms	carbaryl spray or granules	8	Apply in late July or August when worms are present. Use 120 gallons of water per acre.
	diazinon spray or granules	4	
	chlorpyrifos spray or granules	1	
	trichlorfon spray or granules	5	
	Aspon spray	4	

Insecticides: Names and Some Commercial Formulations

Common name	Trade names	Formulations
acephate[a/]	Orthene	75% W.
Bacillus thuringiensis	Biotrol, Dipel, Thuricide	
carbaryl[b/]	Sevin	80% S. 50% W.
chlorpyrifos	Dursban, Lorsban	2 lb./gal. 4 lb./gal. 1% G.
diazinon[c/]	Spectracide, Diazinon	4 lb./gal. 25% E.C. 50% W. 14% G. 5% G.
dicofol	Kelthane	18.5% E.C. 18.5% W.
dimethoate[d/]	Cygon, De-Fend	2 lb./gal. 25% W.P.
endosulfan	Thiodan	2 lb./gal. E.C. 50% W.
malathion[e/]	Cythion	50-57% E.C. 25% W.
superior oil	many brands	...
trichlorfon	Dylox, Proxol	80% W. 4 lb./gal. 5% G.
	Aspon	13% E.C. 6 lb./gal.
	Imidan	50% W.

a/ Do not use on sugar or Japanese maple, flowering crab, or redbud.
b/ Do not use on Boston ivy.
c/ Do not use on ferns or hibiscus.
d/ Do not use on chrysanthemums.
e/ Do not use on canaert red cedar.
Note: E.C. = emulsion concentrate; W. = wettable powder; G. = granules;
S. = sprayable powder.

The above-named insecticides are *not* in the restricted-use category, which would require an applicator to be certified before purchasing or using the insecticide.

For Your Protection

1. Store insecticides out of reach of children, irresponsible persons, or animals; store preferably in a locked cabinet.

2. If you use a bait around or in the home, place it after the children have retired and pick it up in the morning before they get up. Furthermore, place it out of their reach. At present, we do not encourage use of baits for insect control.

3. Avoid breathing insecticide sprays and dusts over an extended period. This is particularly true in enclosed areas such as crawl spaces, closets, basements, and attics.

4. Wash with soap and water exposed parts of body and clothes contaminated with insecticide.

5. Wear rubber gloves when handling insecticide concentrates.

6. Do not smoke while handling or using insecticides.

7. Leave unused insecticides in their original containers with the labels on them and in locked cabinets.

8. Wash out and bury or burn and haul to the refuse dump empty insecticide containers.

9. Do not leave puddles of spray on impervious surfaces.

10. Do not apply insecticides to fish ponds.

11. Do not apply insecticides near dug wells or cisterns.

12. Observe all precautions listed on the label.

Prepared by entomologists of the Illinois Cooperative Extension Service and Illinois Natural History Survey.

NHE-88

FLY CONTROL ON POULTRY FARMS

In most caged layer plants, conditions are ideal for fly breeding. As a result, the fly problem is greater than in litter-floor poultry operations. House flies and lesser house flies predominate, but blue bottle flies, green bottle flies, and flesh flies are also abundant.

Good sanitation is the basis for successful fly control on poultry farms. Removing the manure at least once each week and spreading it out to dry is an effective practice. But it may conflict with other practices in caged laying operations, and thus other measures must be considered. If cleaning is done less than once a week, leave a residue of manure 4 to 6 inches deep in the pits. This allows for survival of predator insects and possibly disease organisms that attack the fly maggots and eggs. These natural enemies will help to slow the build-up of future fly populations. Fly breeding in cage laying operations can be reduced by keeping the manure dry. If the first droppings can be kept dry, additional droppings will tend to build up into cones that provide a greater surface area and help in drying. Other methods of reducing moisture in the building must be used if fly breeding is to be kept to a minimum. One way is to eliminate dripping of water and prevent rain from blowing into the house.

In contrast, cages with trays or pits beneath, having sufficient water to cover and dissolve bird droppings, do not provide as suitable a breeding site for the common flies. However in liquified manure, psychoded flies (moth flies, drain flies, filter flies) and syrphid flies (adults of the rat-tail maggots) can present problems. Exclude flies from entering poultry houses by using screens on all doors and windows. Keep the screens in good repair. Ingress of flies can present major problems.

Fly control programs should be started early in the season before fly populations become heavy.

ADULT FLY CONTROL

Surface sprays. Spray the house ceiling and walls to the point of run-off with 1.0 percent ronnel (Korlan), 1.0 percent stirofos (Rabon) or 1.25 percent stirofos plus dichlorvos (Ravap). Add 5 pounds of sugar or syrup for increased effectiveness. See following table for dilutions. Two other insecticides, dimethoate (Cygon) and fenthion (Baytex), will be effective longer than ronnel, and about the same length as stirofos, but they cannot be used when birds are in the house. When spraying ronnel or stirofos, collect all eggs first, and avoid contaminating feed and water.

Insecticide	Amount in 25 gal. of water	
ronnel 24% E.C.	1 gal.	+ 5 lbs. sugar or syrup
ronnel 25% W.P.	8 lbs.	+ 5 lbs. sugar or syrup
stirofos 24% E.C.	1 gal.	
stirofos 50% W.P.	4 lbs.	
stirofos & dichlorvos 29% E.C.	1 gal.	
dimethoate 23% E.C.	4 gal.	
fenthion 45% E.C.	3 gal.	

SPRAY BAITS, AND BAIT STATIONS, AS SUPPLEMENTARY MEASURES

Spray bait. To make a spray bait, mix 4 ounces of ronnel 24 percent emulsion concentrate, 4 ounces of dichlorvos 23 percent emulsion concentrate or 2 ounces of naled 37 percent emulsion concentrate with 1/2 gallon of warm water, then mix with 1 gallon of corn syrup. Apply the baits to favorite fly resting areas, but keep them out of reach of birds. If the bait mixture will not pass through a small tank sprayer readily, remove the nozzle and whorl disc and apply a straight stream.

Spray Baits and bait Stations as Supplementary Measures: Spray Bait: To make a spray bait, mix 4 ounces of ronnel 24 percent EC, 4 ounces of dichlorvos 23 percent EC or 2 ounces of naled 37 percent EC with 1/2 gallon of warm water, then mix with 1 gallon of corn syrup. Apply the baits to favorite fly resting areas, but keep them out of reach of birds. If the bait mixture will not pass through a small tank sprayer readily, remove the nozzle and whorl disc and apply a straight stream.

Bait stations are especially designed for caged layer operations and are not safe for use in conventional flock management operations.

A simple bait station can be constructed from a chicken water dispenser. A dispenser consisting of a 6-inch diameter plastic device fitted with either a 1- or 2-quart canning jar is ideal. Fill the quart jar nearly full of water; add 4 ounces of granulated sugar and mix. Then add 1 teaspoon of 20-25 percent dichlorvos (DDVP, Vapona) emulsion concentrate. To keep dead flies from accumulating in the trough, cut and fit a cellulose sponge into the trough so that the edge of the sponge nearest the jar is 1/2 inch higher than that nearest the rim. Dying flies will roll off the moist sponge. Use approximately one dispenser per 1,000 square feet, and locate them at sites that attract flies.

Another type of bait station may be made from plastic-impregnated screening commonly used on poultry farms. Punch several holes 1/8 to 1/4 inch in diameter in a piece of screening 4 inches square; staple this screen to a wooden tongue depressor so that about half of the depressor projects beyond it. Bend the screen slightly to shield one surface from rain and droppings. Then coat this surface with the toxic bait. When the bait dries, the portion that flows through the holes will anchor it to the screen.

Prepare the bait according to the following directions:

5 lb. granulated sugar
5 lb. clean, dry sand
6 oz. 25% ronnel
2 (3 oz.) packages household gelatin (sold in food stores for desserts)
2 1/2 cups hot water

Thoroughly mix the sugar, sand and wettable powder in a dry pail. Dissolve the gelatin in 2 1/2 cups of boiling water in a separate container, and gradually add the dry ingredients. Use a trowel or paddle for mixing--do not expose your bare hands to insecticides. The bait should have the consistency of a thick paste. If it is too wet it will not adhere to the screen, and if it is too dry it may crumble. Apply the bait to the screen with a paddle or old knife, and let it dry overnight. This amount of bait will be sufficient for about 150 stations.

You can sharpen the free end of the tongue depressors and push them into the ground at the edge of manure piles or hang them from the cages as near the ground as possible. Or you can tack them to the cage supports below and out of reach of poultry. Use at least one bait station per 10 feet, and more in places where flies are congregating.

A cheap grade of cotton or burlap, in strips 2 or 3 inches wide and about 30 inches long, treated with the bait paste will also serve as bait stations. These strips can be tacked in high places where flies gather rather than on and near the floor.

Baits, and bait stations, are not satisfactory for use where fly populations are heavy. They should be considered only as a supplement to good sanitation and residual wall sprays.

MAGGOT CONTROL

Frequent removal of manure is basic to good control of maggots.

Most insecticides used against adult flies will also kill fly maggots. However, we do not recommend using the same insecticides for adults as for maggots, since fly resistance will then build up faster.

Maggots die from natural causes, such as diseases, predators, parasites, and adverse physical conditions. Only a small fraction of those that hatch reach the adult stage under normal conditions.

One material not used against adult flies that is effective against maggots is thiourea. Add 1 pound of thiourea to 12 gallons of water, and apply at the rate of 1 gallon per 100 square feet of manure. Eight to 12 gallons will treat a 1,000-caged-layer operation. For best results, repeat the treatment every two weeks. Do not spray the birds.

A dust form of a mixture containing 1 part calcium cyanamid and 1 part 20 percent superphosphate applied at the rate of 1/2 pound per bushel of manure is also effective. It is best to use if manure is wet.

As an alternative, dichlorvos (DDVP) may be used as a larvicide without a great risk of increasing fly resistance. To use mix 1 quart of the 23 percent liquid concentrate in 12 gallons of water and apply at the rate of 2 gallons per 1,000 square feet of manure surface. Repeat treatments may be needed as often as every 2 weeks.

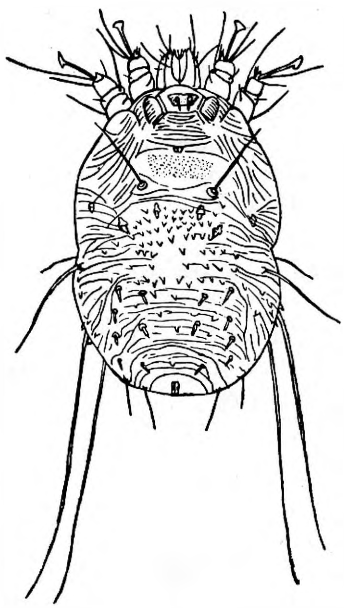
Prepared by entomologists of the Illinois Cooperative Extension Service and Illinois Natural History Survey. For additional copies, see your Extension adviser in agriculture.

HUMAN SCABIES

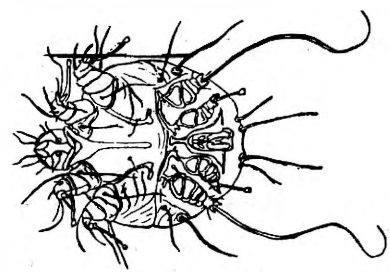
Common Names: Human itch mite
Human scabies mite
Seven-year itch

Scientific name: *Scarcoptes scabiei hominis*

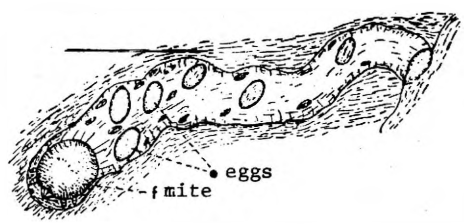
DESCRIPTION The mites are tiny, whitish animals scarcely visible to the naked eye. They have a nearly round body shape, with stiff projecting bristles and small, pincer-type mouth parts. They have four pairs of short, stumpy legs with a sucker-like organ on the first two pairs of legs in the female and on the first, second, and fourth pairs of legs in the male. Female mites are about 1/50 of an inch and male mites about 1/100 of an inch long.



Human itch mite—female. (Actual size, 1/50 of an inch.)



Human itch mite—male. (Actual size, 1/100 of an inch.)



Mite burrow, with eggs and female mite at end of burrow. (Actual size, 1/8 of an inch.)

LIFE CYCLE AND HABITS The adult female mites burrow in the surface skin, making tunnels that may be a fraction of an inch to over an inch in length. They lay 1 to 3 eggs per day in the burrow for three to five weeks, the average life span for adult mites. The eggs hatch in 3 to 4 days, giving rise to the larval mites, which have 3 pairs of legs. In another 2 to 3 days, the larval mites transform into the nymphal stage mites, which have 4 pairs of legs. The nymphal mites molt twice, becoming adult mites in 4 to 6 days. The larval and nymphal mite stages make only short, shallow burrows in the skin.

The development time from egg to adult takes 8 to 15 days; however, the length of time required to produce a new generation of mites is estimated at about three weeks. The potential to produce large numbers of mites exists but seldom does the number of adult female mites exceed 30 per person.

The mites invade the skin between the fingers, wrists, and elbows in about 85 percent of the cases. They also attack the skin in the region of the groin and external genitals, back of the knees, and the ankles and toes. In children all parts of the body may be infested, while in women the undersides of the breasts and buttocks are also favorite locations for the mites. The head is rarely attacked. Mites that cause mange on other animals such as dogs, cattle, horses, swine, and sheep may live for a day or two on humans, but they do not become established or reproduce.

SYMPTOMS AND INJURY Intense itching, especially at night when warmth causes greater mite activity, is a common sign of scabies. Scratching and the effects of scratching, which can lead to greater irritation and possibly secondary infections, may be more serious than the mites. Visual symptoms include redness of the skin with small raised areas resembling tiny blisters (vesicles) that contain a serous fluid. The overall effect is rash-like. It probably takes 4 to 6 weeks after infestation before these symptoms become apparent. A *tentative diagnosis* can be based upon these symptoms and their locations (finger webbing, wrists, elbows). However, a *positive diagnosis* can only be made by finding the mites, their eggs, or burrows by a microscopic examination of scrapings or a skin biopsy preparation. This should be done by a physician.

TRANSMISSION Scabies is transmitted from person to person by actual contact, usually at night by people who share a bed. Spread through bedding and clothing is rare. If one family member has scabies, it is highly probable that other members of the family are also infested. Transmission from family to family generally occurs via children who have close contacts as playmates. Other persons outside the family who have close contacts with family members may be infested.

TREATMENT AND CONTROL (These suggestions are taken from Illinois Department of Public Health recommendations.) See your physician for a positive diagnosis if you suspect you have scabies. A one-percent lindane lotion (Kwell) will provide effective control of scabies in most cases. It is available only by a doctor's prescription from a pharmacy.

For successful results the lindane should be used in the following manner. *All persons having close contact with the affected person should be treated simultaneously.*

1. Take a warm, soapy bath and towel dry.
2. Apply the one-percent lindane lotion to every square inch of skin from the chin to the toes and leave on undisturbed (do not wash) for 24 hours.
3. If the scalp is involved (most common in infants), use a lindane shampoo. The shampoo can be used over the entire body, and then rinsed off in a few minutes.
4. Change to clean clothing after the treatment.
5. Wash all used bedding and clothing in hot, soapy water or dry clean them.
6. Repeat the treatment in 7 days.

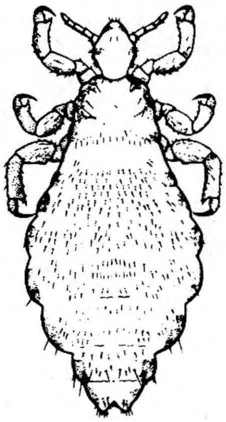
Prepared by entomologists of the Illinois Cooperative Extension Service and Illinois Natural History Survey. For additional copies, see your Extension adviser in agriculture.

HUMAN LICE

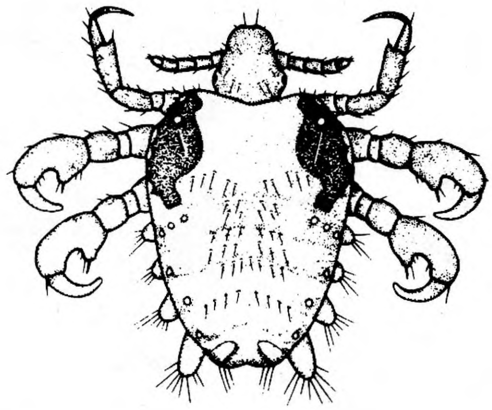
Common Names:	Body louse	*SCIENTIFIC NAMES:*	*Pediculus humanus humanus*
	Head louse		*Pediculus humanus capitis*
	Crab or pubic louse		*Phthiris pubis*

DESCRIPTION. It is difficult to tell the body louse and head louse apart. Both are grayish, flattened insects 1/16 to 1/8 inch long and about half as wide as long. The head louse lives on the skin among the hairs of the head including the eyebrows while the body louse lives in clothing going on the skin only to feed. The crab louse is grayish-white with dark legs and shoulders about 1/16 inch long and about two-thirds as wide as long. They occur in the hairs of the pubic regions, beneath the armpits, and with heavy infestations, on the hairs of the legs and arms. When magnified, the legs of lice appear stout and end in a single claw used for grasping hairs.

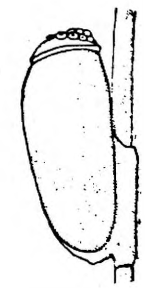
Louse eggs or "nits" are oval, about 1/25 inch long, and whitish to yellowish. The eggs are glued to hairs by the head louse and crab louse while the body louse lays its eggs in the seams of clothing.



Body louse and Head louse
(16X natural size)



Crab louse
(30X natural size)



Louse egg or nit
(30X natural size)

LIFE CYCLE AND HABITS. All human lice are blood takers. They feed two to six times each day, and the adult lice live for about a month. A single female crab louse lays 15 to 50 eggs, while a female head or body louse lays from 50 to 300 eggs. The eggs usually hatch in about a week, and the young lice take 1 to 4 weeks to mature. The life cycle takes from 14 to 35 days. Lice infestations are generally more prevalent in winter or when people are crowded together for long periods. However, lice can present problems at any time, and all stages of lice may be found at any season of the year. The body louse can sometimes live without feeding for several weeks in moist clothing or bedding. In contrast head lice and crab lice die within a few days at room temperatures off a person. Eggs do not hatch below 70° F. and if held below 60° F. for a week, they do not hatch even if warmed.

DETECTION AND TRANSMISSION. Intense itching and inflamed spots or the feeling of something crawling on the skin is a sign that lice may be present. Inspect the suspect areas and clothing for the presence of minute grayish specks. Examine the specimens with a reading glass or hand lens to make a positive identification. A check of the hair areas may reveal louse eggs (nits). The eggs will be attached to the hairs close to the skin.

Head lice can be contracted from the use of infested items like combs, brushes, wigs, hats, or towels. Body lice are spread in infested clothing or bedding. Crab lice are acquired from intimate contact with an infested person.

INJURY. The bites from lice, although hardly felt, are usually irritating. Severe scratching can lead to secondary infections, and scarred, thickened skin with brown or blue-gray spots. This condition is known as "pediculosis." The body louse is capable of transmitting typhus fever.

CONTROL. Louse control is best handled by a physician. Body lice and their eggs are killed by washing and heat-drying or dry-cleaning clothing and bedding. Change clothing and bedding every 3 or 4 days and launder. Repeat until body lice disappear. For head lice or crab lice, dust infested areas lightly with 1-percent malathion or 5-percent carbaryl (Sevin). Repeat the treatment in about 10 days.

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CRICKETS

COMMON NAMES:		*SCIENTIFIC NAMES:*	
	House cricket		*Acheta domesticus*
	Field crickets		*Gryllus spp.*
	Camel cricket		*Ceuthophilus maculatus*
	Mole cricket		*Gryllotalpa hexadactyla*

DESCRIPTION. In general, the crickets resemble grasshoppers in that they both have long tapering antennae, a streamlined body, and long gangling powerful rear legs that look as if they are attached backwards. Crickets range in size from 1/4 to 1/2 inch and on up to about 2 inches. They vary in color from a light brown to black. Many crickets are well-known songsters. Each species has a characteristic song or chirp. Most species live out the winter as eggs laid in the ground or in vegetation.

HABITS. Crickets have the ability to ruin a wide variety of fabrics, foods, and paper products in addition to their annoying chirping. They will eat nearly anything, including the wool in carpets and sizing from wallpaper, fruits, vegetables, the glue from bookbindings, meat, and other crickets.

House crickets cause the real damage. They are light yellowish-brown in color and are about 3/4 of an inch long. They prefer warm dark places in buildings, often hiding in cracks and underneath objects until the early evening when they begin their activity. The adult house crickets are able to fly and jump considerable distances. They also crawl up the sides of buildings. They have no trouble getting into apartments above the ground floor.

One of the key things to remember is that house crickets can set up housekeeping in a structure. This means that they are capable of reproducing indoors.

With *Field crickets,* the situation is a little different. They enjoy the outdoors. However, they do find their way indoors when their food supply dwindles and the weather turns cold. Field crickets are not adapted to indoor living, so their population within a structure will die out as the season progresses. Two other crickets found in homes are the camel cricket, also called the "cave" or "stone" cricket, and the mole cricket.

Camel crickets are brownish and rather humpbacked in appearance. Their antennae are often extremely long. Camel crickets prefer outdoor areas that are cool, damp, and dark. They often live under rocks or logs. They invade the house, and can build fairly large populations in damp cellars and unused fireplaces. Firewood is very often a "Trojan horse" for this species of cricket.

Mole crickets are about 1-1/2 inches long, and look just the way their name suggests. They have beady eyes and front legs for digging that are short, very broad, and spadelike. They are very poor jumpers and flyers. During the cold weather, they remain in their moist burrows usually 6 to 8 inches below the soil surface. When the sod is flooded or extremely wet from excessive rains, mole crickets leave their burrows and make short excursions on the soil surface at night. During these periods, they sometimes enter basements and the ground floor of dwellings.

PREVENTION AND CONTROL. Preventing the crickets from invading your home is the secret to control. The Cooperative Extension Service recommends foundation spraying to guard against an invasion of insects. Suitable insecticides are readily available from your local garden center, hardware, or farm supply store.

Spray approximately 2 to 3 inches up on the foundation to the point of runoff, and then a couple of inches out onto the soil. The requirement for an average-size house is about 4 to 6 gallons of the diluted spray.

Cricket control indoors can be accomplished by spraying cracks and crevices such as baseboards, door thresholds, and the like with an aerosol can preparation of a recommended insecticide. For information on recommended insecticides, consult Illinois Extension Circular 900, *Insect Pest Management Guide—Home Yard and Garden.*

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WHITEFLIES ON HOUSE PLANTS

COMMON NAMES: Greenhouse whitefly
Whitefly

SCIENTIFIC NAME: *Trialeurodes vaporarioram*

DESCRIPTION

Adult whiteflies range in size from 1/10 to 1/16 inch. Their milk-white appearance is a result of a powdery, waxy material covering their body. They have four broad, very delicate wings, which are held tentlike over their body when resting. When disturbed they quickly flutter about, resembling bits of ashes or tiny snow flakes. Whiteflies very often occur in great numbers, and when a heavily infested plant is shaken, they immediately take to the air, producing a small cloud of whiteflies.

Whiteflies are plant-sucking insects. The mature and immature stages feed by inserting their mouthparts into the plant and sucking out plant sap.

The nymphs, or immature stage of the whitefly, usually attach themselves to the underside of a leaf. They appear oval and flat and are covered with a white, waxy secretion which gives them the appearance of a tiny scale.

LIFE CYCLE AND HABITS

In warmer areas of the country, whiteflies reproduce twelve months a year. In the more northern climates, however, they can survive only in greenhouses or on a houseplant indoors where they are protected from freezing. In a greenhouse or inside homes, whiteflies will produce throughout the year.

Each female whitefly has the capability of laying as many as 400 eggs. The eggs are usually laid in groups of 40 and are often deposited in a circle. In 4 to 12 days, depending on temperatures and humidity, the eggs hatch into flattened, nearly transparent crawlers, which move about on the undersides of the leaves. In a short time, they settle down, insert their mouthparts into the leaf, and begin to feed. They quickly molt, losing their legs in the process, and attach themselves firmly to the underside of the leaf with small waxy rods. They remain in this stage for about four weeks. Upon emerging, adult whiteflies immediately begin to produce fine, waxy threads from a gland at the base of the abdomen. Using their forelegs, they distribute this wax over their entire body. Soon after emerging, adult whiteflies feed and then begin to mate. Adult whiteflies live for 30 to 40 days.

NATURE OF INJURY

Whiteflies damage plants by sucking out plant juices. Very heavy infestations may cause yellowing and even drying of leaves or may interfere with photosynthesis. The insects excrete a thick, sweet, sticky juice called honeydew. This material will cover the entire leaf surface and serves as a medium for the growth of a black, sooty mold, which shades the leaves and interferes with the normal plant growth process--photosynthesis. Heavily infested plants will be stunted and produce small or inferior crops. The leaves of infested plants will have poor color and drop prematurely. Plants attacked include cucumber, squash, eggplant, tomato, lettuce, geraniums, fuchsia, ageratum, hibiscus, coleus, begonia, and many other plants.

CONTROL

When purchasing house plants, inspect them thoroughly. It certainly is a good idea to isolate all new house plants for at least 30 days before mixing them with established plants. If an infestation develops, it is best to discard the plant or attempt to eliminate the whiteflies.

Carefully check outdoor garden plants the same way. Once whitefly infestations occur in your garden, control is very difficult and may require four or five applications of an insecticide at five-day intervals. Insecticides containing pyrethrin labeled for home and garden use and labeled for use on plants will control the adult stage of whiteflies. Use only formulations registered for use on whiteflies and for use on the specific plant species infested. Washing with soapy water and a soft brush will reduce or eliminate whiteflies on a plant. Use 2 teaspoons of a mild detergent per gallon of water. Rinse plants with clear water after washing.

Prepared by entomologists of the Illinois Cooperative Extension Service and Illinois Natural History Survey. For additional copies, see your Extension adviser in agriculture.

1978 TURFGRASS PEST CONTROL

With the introduction of improved management techniques and new, more effective materials, turfgrass culture has developed into a highly sophisticated technology. Among the new materials are the modern pesticides that control weeds, diseases, and insects. Proper irrigation, mowing, and fertilization practices remain the principal defenses against turfgrass pests; it is sometimes necessary, however, to complement the turfgrass cultural program with the intelligent selection and use of pesticides.

Pesticide formulations. Pesticides are chemicals that are active against one or more turfgrass pests. These chemicals are generally formulated as liquid concentrates — solutions (S) and emulsifiable concentrates (EC) — wettable powders (WP), and granules (G). Liquid concentrates and wettable powders are usually added to water and applied to the turf with a sprayer. Granular materials can be applied with a fertilizer spreader.

Active ingredients. Pesticides must be accurately applied at correct rates to yield optimum results. Too little may control pests ineffectively; too much may injure the turf. The specific amount of material that should be applied depends upon the concentration of the pesticide (the "active ingredient") in the commercial preparation.

Concentration is usually expressed as a weight per unit volume or as a percent of the commercial preparation. For example, a 50 percent wettable powder is 50 percent active ingredients (a.i.) and 50 percent inert carrier. If the recommended rate of application is 12 pounds a.i. per acre, then 24 pounds of this commercial preparation are required to treat one acre. This is roughly equivalent to ½ pound per 1,000 sq. ft. (43,560 sq. ft. = 1 acre).

Liquid formulations generally list the number of pounds of the active ingredient per gallon (lb. a.i./gal.) on the pesticide label. If the concentration is 4 lb./gal., then one quart of the product is required per acre to supply 1 pound of active ingredient per acre.

Precautions. Pesticides should be stored in their original containers with the label securely attached. Keep them in a cool, dry place that is inaccessible to children, pets, and irresponsible persons. Read the label before using the pesticide and follow all instructions carefully. A few minutes spent studying the information on a pesticide label may prevent misuse and needless accidents.

WEED CONTROL

Herbicides are pesticides that control one or more plant species. They may be classified into one of three types — contact, systemic, or soil sterilant — depending upon the nature of their activity on plants.

Table 1. — Chemical Control of Broadleaf Weeds in Turf

	2,4-D[a]	Silvex[b]	Mecoprop[c]	Dicamba[d]
(S = susceptible; I = intermediate control; R = resistant)				
Black medic	R	S-I	I	S
Carpetweed	S	I	I	S
Chickweed,				
common	R	S	S-I	S
mouse-ear	R	S	S-I	S
Chicory	S	S	S	S
Daisy, oxeye	I	I	I	I
Dandelion	S	S	S-I	S
Dock, curly	I	I-R	I-R	S
Ground ivy	I-R	S-I	I	S-I
Hawkweed	S-I	R	R	S-I
Henbit	I	S	I	S
Knotweed	R	I	I	S
Lambsquarters	S	S	S	S
Mallow, roundleaf	I-R	S-I	I	S-I
Plantain,				
broadleaf	S	I	I-R	R
buckhorn	S	I	I-R	R
Purslane	I	S-I	R	S
Red sorrel	R	I	R	S
Speedwell,				
creeping	R	R	R	R
purslane	I	I	I	I
Spurge, prostrate	I-R	I	I	S-I
Thistles	S-I	S-I	I	S
White clover	I	S	S	S
Wild carrot	S	S-I	S-I	S
Wild onion	I	R	R	S-I
Woodsorrel, yellow	I	S-I	I	I
Yarrow	I	I-R	I-R	S

[a] A basic herbicide for use in combination with one or more of the others for broad-spectrum postemergence control of broadleaf weeds. Standard rate of application is 1 lb./A. Not recommended for use on bentgrass putting greens.
[b] Should not be used on bentgrass turf. Apply at ½ to ¾ lb./A. plus 2,4-D at the standard rate.
[c] Safe for use on bentgrass putting greens at ½ to 1 lb./A. during cool weather periods. Can apply to general turf at 1 lb./A. with 2,4-D.
[d] A very effective herbicide for broadleaf weed control when combined with 2,4-D or as a 3-way combination. Use at ¼ lb./A. with 2,4-D; use at ⅛ lb./A. with 2,4-D+silvex or with 2,4-D +mecoprop. Do not apply above roots of trees and shrubs.

Contact herbicides kill plant parts covered by the chemical. Paraquat, a contact herbicide, is useful in renovating turfs infested with extensive populations of annual weeds. Because paraquat has low soil residual activity, treated areas may be reseeded soon after chemical application.

Systemic herbicides, absorbed by plant organs and translocated throughout the plant, may be either *selective,* killing certain weeds without injuring desirable grasses, or *nonselective,* controlling all vegetation. Mecoprop is a selective herbicide used to control broadleaf weeds in turf. Dalapon, a nonselective herbicide, is used

Prepared by J. R. Street, Assistant Professor, and A. J. Turgeon, Associate Professor, Department of Horticulture; M. C. Shurtleff, Professor, Department of Plant Pathology; and R. Randell, Associate Professor, Agricultural Entomology.

to kill perennial weedy grasses such as quackgrass that cannot be controlled by selective herbicides.

Soil sterilants are chemicals that render the soil toxic to all plant life. How long the soil remains sterile depends upon the material used, the rate of application, and the prevailing environmental conditions that affect decomposition of the herbicide in the soil. Soil sterilants have no place in turfgrass management; however, they are useful in preventing plant growth under fences and other areas that are difficult to mow.

Herbicides may be applied to prevent weeds from infesting a turf or to control weeds already present. Bensulide is a *preemergence* herbicide applied in spring to prevent development of crabgrass. Once the weed has germinated, DSMA may be used as a *postemergence* treatment to selectively control the crabgrass invader.

INSECT CONTROL

Insecticides are pesticides that reduce insect populations below levels that are injurious to turf. Although insecticide chemistry is quite varied, most of the commonly used materials act as contact poisons. Effective control is dependent upon ensuring contact between the insect and

Table 2. — Chemical Control of Weed Grasses in Turf

Weeds	Life length	Herbicide	Rate (lb. a.i. per acre)	Remarks
Annual bluegrass	annual or perennial	benefin (Balan)	3	Apply in early spring and late summer. Do not use on bentgrass putting greens.
		bensulide (Betasan)	10	Apply in late summer before the return of cool weather to prevent development of new plants. Fairly safe for use on bentgrass putting greens.
		DCPA (Dacthal)	12	Apply in early spring and late summer. Do not use on bentgrass putting greens.
		endothall (Endothal)	¾	Apply during warm weather in late summer to Kentucky bluegrass turf. Repeat in two weeks if necessary. After last application, as annual bluegrass turns brown, overseed with desirable grasses or insert plugs of sod into large bare areas to promote rapid healing. Has little or no preemergence activity.
Crabgrass Foxtails Barnyardgrass	annual	benefin (Balan)	2	Apply before emergence of crabgrass in early spring. Not recommended for use on bentgrass turf.
		bensulide (Betasan)	10	Apply before emergence of crabgrass in early spring.
		DCPA (Dacthal)	12	Apply before emergence of crabgrass in early spring. May injure bentgrasses and fine-leaf fescues.
		siduron (Tupersan)	10	Apply before emergence of crabgrass in early spring. Use at half the recommended rate in conjunction with seeding Kentucky bluegrass. May injure some bentgrasses and fine-leaf fescues. Do not use on bermudagrass.
		organic arsenicals (DSMA, MSMA, etc.)	follow labels	Apply soon after emergence of crabgrass. Three applications at 7- to 10-day intervals are usually required. May cause some discoloration of the turf.
Goosegrass	annual	DCPA (Dacthal)	15	Goosegrass is harder to control than crabgrass; complete control is rarely achieved. Better control may result if a second application is made at half rate in early June.
		organic arsenicals (DSMA, MSMA, etc.)	follow labels	Apply soon after emergence. Three or more applications at 7- to 10-day intervals may be required for control. May cause some discoloration of the turf.
Bentgrass Nimblewill Tall fescue Quackgrass Bermudagrass	perennial	amitrole dalapon amitrole + dalapon glyphosate	4 10 2 + 5 2	These give nonselective control. Amitrole and dalapon may persist in the soil for up to 4 and 6 weeks, respectively. Overseeding should be delayed until chemical residues have dissipated. Glyphosate has no residual activity in the soil; repeated treatments may be necessary for complete control.
Nutsedge	perennial	organic arsenicals (DSMA, MSMA, etc.) 2,4-D + organic arsenicals	follow labels follow labels	Treat soon after emergence before new nutlets form. Repeat application as soon as new growth is evident. Precede chemical treatment with intensive irrigation for several days to enhance control.

the insecticide. Therefore, control of soil-inhabiting insects (such as grubs) is best achieved by drenching the insecticide into the soil, whereas foliar-feeding insects (for example, sod webworms) should be controlled by a foliar spray with no irrigation or rainfall for at least 24 hours.

Most insecticide applications are for control — the insect is controlled after the early signs of injury have been observed. No single insecticide will control all insect pests found in turf. Identify the specific insect before attempting control with an insecticide. Learn to recognize the early signs of injury from insects to avoid wide-scale loss of turf.

DISEASE CONTROL

Fungicides are pesticides that kill or inhibit the growth of disease-causing fungi. Depending upon the manner in which they protect plants against infection, fungicides are of two general types: protective-contact fungicides and systemic fungicides.

Protective-contact fungicides are applied to seed, foliage, or soil to keep disease-causing fungi from entering plants. This kind of fungicide must be applied fairly frequently to turf (7- to 14-day intervals) since mowing and irrigation remove much of the surface chemical soon after application. Relatively high spray volumes (5 gal. water per 1,000 sq. ft.) are required to supply uniform and continuous coverage of the foliage by the fungicide. Adding spreader-stickers (surfactants) to the spray mixture facilitates good foliar coverage. Most of the available fungicides for turf are the protective-contact type.

Systemic fungicides, or chemotherapeutants, are absorbed and distributed within the plant, destroying established infections and controlling certain diseases for several weeks or months. These fungicides are absorbed principally by the roots and hence should be drenched or watered in for best results. Examples of systemic fungicides are benomyl (Tersan 1991), chloroneb (Tersan SP), and etridiazole (Koban).

Table 3. — Chemical Control of Insects

Insect	Insecticide[a]	Dosage per 1,000 sq. ft.[b]	Suggestions
White grubs	diazinon 25% EC	1 cup	Apply as spray or granules to small area and then water in thoroughly before treating another small area. Grub damage will usually occur in late August and September.
	5% G	2½ lb.	
	trichlorfon (Dylox, Proxol) 80% SP[c]	½ cup	
	5% G	3¾ lb.	
Cicada killer and other soil-nesting wasps; Ants	diazinon 25% EC	¾ cup	Apply as spray or granules and water in thoroughly. For individual nests pour 1% diazinon in nest and seal in with dirt.
	2% G	5 lb.	
Sod webworms	carbaryl (Sevin) 50% WP	½ lb.	Webworms usually damage lawns in late July and August. As sprays, use at least 2½ gal. water per 1,000 sq. ft. Do not water for 72 hours after treatment. As granules, apply from fertilizer spreader.
	5% G	4 lb.	
	diazinon 25% EC	¾ cup	
	2% G	5 lb.	
	chlorpyrifos (Dursban) 2% EC	1½ fl. oz.	
	½% G	5 lb.	
	trichlorfon (Dylox, Proxol) 80% SP[c]	⅓ cup	
	5% G	2½ lb.	
	Aspon 13% EC	1⅓ cups	
Millipedes and sowbugs	carbaryl (Sevin) 50% WP	½ lb.	Spray around home where millipedes or sowbugs are crawling. If numerous, treat entire lawn.
	5% G	4 lb.	
	diazinon 25% EC	¾ cup	
	2% G	5 lb.	
Armyworms; Cutworms	carbaryl (Sevin) 50% WP	2 oz.	Apply as sprays or granules. Use 5 to 10 gal. of water per 1,000 sq. ft.
	5% G	1 lb.	
	chlorpyrifos (Dursban) 2% EC	1½ fl. oz.	
	½% G	5 lb.	
	trichlorfon (Dylox, Proxol) 80% SP[c]	⅓ cup	
	5% G	2½ lb.	
Chinch bugs	chlorpyrifos (Dursban) 2% EC	1½ fl. oz.	Spray infested areas where chinch bugs are present.
	Aspon 13% EC	⅔ cup	
	trichlorfon (Dylox, Proxol) 80% SP[c]	⅓ cup	
Aphids	malathion 50% to 57% EC	1 tbsp.	Spray grass thoroughly.
Chiggers	diazinon 25% EC	1 tbsp.	Spray grass thoroughly.
Slugs	Mesurol 2% bait		Apply where slugs are numerous. Scatter in grass. For use only in flower gardens and shrubbery beds.

[a] Use any of the insecticides recommended for a given group of insects, being sure to use the proper dosage for the formulation chosen. Follow labels.
[b] To determine lawn size in square feet, multiply length times-width of lawn and subtract non-lawn areas including house, driveway, garden, etc. Do not allow people or pets on lawn until the spray has dried.
[c] Applied by commercial applicators only.

Table 4. — Chemical Control of Turfgrass Diseases

Diseases[a]	Principal turfgrasses affected	Normal season and intervals of application	Fungicide preparations (oz. per 1,000 sq. ft.)[b]
Helminthosporium diseases			
Melting-out (*H. vagans*)	Fescues Kentucky bluegrass Ryegrasses	March-June; Sept.-Nov. 5 to 14 days	Acti-dione Thiram (2 to 4 oz.) Acti-dione TGF (2 oz.) Bromosan WP 50% (2 to 4 oz.) Daconil 2787 WP 75% or 6F (4 to 8 oz.) Difolatan 4F (4 to 6 oz.) Dyrene WP 50% (4 to 6 oz.) Fore WP 80% (3 to 6 oz.) Kromad WP (3 to 6 oz.) Spectro WP 50% (3 to 6 oz.) Tersan LSR WP 80% (3 to 6 oz.) zineb WP 75% (4 to 6 oz.)
Helminthosporium leaf spot (*H. sorokinianum*)	All turfgrasses	June-August 7 to 14 days	
Zonate eyespot (*H. giganteum*)	Bermudagrass Bluegrasses Fescues Ryegrasses	July-Sept. 7 to 14 days	
Helminthosporium blight (*H. dictyoides*)	Bluegrasses Fescues Ryegrasses	April-July 7 to 14 days	
Brown blight (*H. siccans*)	Fescues Ryegrasses	April-June 7 to 14 days	
Leaf blotch (*H. cynodontis*)	Bermudagrass	April-June 7 to 14 days	
Red leaf spot* (*H. erythrospilum*)	Bentgrasses	June-August 7 to 14 days	*Daconil 2787 or 6F is the only fungicide effective against *H. erythrospilum*.
Fusarium blight (*F. roseum* f. sp. *cerealis* "culmorum" and *F. tricinctum* f. sp. *poae*)	Bentgrasses Bluegrasses Fescues Ryegrasses	June-August	Chipco Spot Kleen WP 70% (4 to 6 oz.) Cleary's 3336 WP 50% (4 to 8 oz.) Fungo WP 50% (4 to 8 oz.) Tersan 1991 WP 50% (5 to 8 oz.)
		Comments: Apply when disease is expected or first appears. Repeat in 14 to 21 days if necessary. Drench fungicide into root zone using ½ inch (300 gal.) of water per 1,000 sq. ft. Water the turf thoroughly the day before (300 to 450 gal. water per 1,000 sq. ft.).	
Sclerotinia dollar spot (*S. homoeocarpa*)	All turfgrasses	May-Nov. 7 to 14 days	Acti-dione Thiram (2 to 4 oz.) Acti-dione TGF (1 to 2 oz.) Bromosan WP 50% (3 to 6 oz.) cadmium compounds (see label) Chipco Spot Kleen WP 70% (1 to 2 oz.) Cleary's 3336 WP 50% (1 to 2 oz.) Daconil 2787 WP 75% or 6F (4 to 8 oz.) Dyrene WP 50% (2 to 6 oz.) Fungo WP 50% (1 to 2 oz.) Kromad WP (3 to 6 oz.) Spectro WP 50% (3 to 6 oz.) Tersan 1991 WP 50% (1 to 2 oz.)
Corticium red thread or Pink patch (*C. fuciforme*)	Bentgrasses Bermudagrass Bluegrasses Fescues Ryegrasses	April-June; August-Nov. 7 to 14 days	
		Comments: Resistance to cadmium compounds, benomyl, thiophanate materials, Dyrene, and other fungicides has been reported in some areas. Using combinations of active ingredients or alternating between products may be advisable.	
Rhizoctonia brown patch (*R. solani*)	All turfgrasses	June-Sept. 5 to 14 days	Bromosan WP 50% (3 to 6 oz.) Chipco Spot Kleen WP 70% (2 to 4 oz.) Cleary's 3336 WP 50% (2 to 4 oz.) Daconil 2787 WP 75% or 6F (4 to 8 oz.) Dyrene WP 50% (6 to 8 oz.) Fungo WP 50% (2 to 4 oz.) Kromad WP (3 to 6 oz.) Spectro WP 50% (3 to 6 oz.) Tersan 1991 WP 50% (2 to 4 oz.)
Leaf smuts			
Stripe smut (*Ustilago striiformis*) Flag smut (*Urocystis agropyri*)	Bentgrasses Bluegrasses Ryegrasses	Late fall	Chipco Spot Kleen WP 70% (4 to 6 oz.) Cleary's 3336 WP 50% (6 to 8 oz.) Fungo WP 50% (6 to 8 oz.) Tersan 1991 WP 50% (6 to 8 oz.)
		Comments: Make two applications, 14 to 21 days apart. Drench fungicide into soil, using 1 inch (600 gal.) water per 1,000 sq. ft., immediately after application.	

[a] Causal fungus listed in parentheses.

[b] Denotes either fungicide, coined name of that material, or representative trade names. Mention of a trade name or proprietary product does not constitute warranty of the product and does not imply approval of this material to the exclusion of comparable products that may be equally suitable. Except where indicated, all materials should be applied in 3 to 5 gal. of water per 1,000 sq. ft. Use lower fungicide rates in *preventive* programs, higher rates for *curative* programs. Only one from each recommended group of preparations need be used. Fungicide use and restrictions are subject to change without notice. Always read and follow the current package label instructions and precautions.

Table 4. — Chemical Control of Turfgrass Diseases (continued)

Diseases[a]	Principal turfgrasses affected	Normal season and intervals of application	Fungicide preparations (oz. per 1,000 sq. ft.)[b]
Anthracnose (*Collectotrichum graminicola*)	All turfgrasses, especially annual bluegrass	June-Sept. 7 to 14 days	Chipco Spot Kleen WP 70% (1 to 2 oz.) Cleary's 3336 WP 50% (1 to 2 oz.) Fungo WP 50% (1 to 2 oz.) Tersan 1991 WP 50% (1 to 2 oz.)
Rusts: leaf and stem (*Puccinia* sp.)	All turfgrasses, especially certain cultivars of Kentucky bluegrass, Perennial ryegrass, Zoysiagrass, and Burmudagrass	July-Oct. 7 to 14 days	Acti-dione Thiram (2 to 4 oz.) Acti-dione TGF (1 to 2 oz.) Daconil 2787 WP 75% or 6F (4 to 8 oz.) Fore WP 80% (2 to 4 oz.) Tersan LSR WP 80% (2 to 4 oz.) thiram WP 75% (2 to 4 oz.) zineb WP 75% (2 to 4 oz.)
Powdery mildew (*Erysiphe graminis*)	Bluegrasses Bermudagrass Fescues	April-Nov. 7 to 14 days	Acti-dione Thiram (2 to 4 oz.) Acti-dione TGF (1 to 2 oz.) Chipco Spot Kleen WP 70% (1 to 3 oz.) Cleary's 3336 WP 50% (1 to 3 oz.) Fungo WP 50% (1 to 4 oz.) Karathane WP 22.5% (1 oz.) Tersan 1991 WP 50% (1 to 3 oz.)
Snow molds			
Typhula blight (*T.* species)	All turfgrasses	Nov.-March see label for interval	Tersan SP WP 65% (6 to 9 oz.) Calo-clor, Calo-Gran (see label)[c]
Fusarium patch (*F. nivale*)			Tersan SP WP 65% (6 to 9 oz.) Tersan 1991 WP 50% (2 oz.) Calo-clor, Calo-Gran (see label)[c]
Pythium blight, grease spot, spot blight (many *P.* species)	All turfgrasses	April-Nov. 5 to 10 days	Koban WP 35% (4 to 8 oz.) Terrazole WP 35% (4 to 8 oz.) Tersan SP WP 65% (4 oz.)
		Comments: Apply fungicide in 5 to 10 gal. water per 1,000 sq. ft.	
Fairy rings (*Marasmius oreades*, *Agaricus* or *Psalliota campestris*, *Lepiota* sp.)	All turfgrasses		methyl bromide chloropicrin Vapam Soil Fumigant Vorlex formaldehyde
		Comments: Soil temperature should be above 60° F. for fumigation. Cover area with gas-proof cover for several days. *or* Instead of treating with fungicide, use root-feeder attachment on hose to drench rings with water. Repeat when symptoms reappear.	
Seed rot, damping-off, seedling blights (*Pythium* sp., *Fusarium* sp., *Rhizoctonia solani*, *Helminthosporium* sp., *Colletotrichum graminicola*)	All turfgrasses	Treat seed before planting.	captan or thiram 50% to 75%, plus Koban WP 35% (see label)
		Spray at early seedling emergence and 7 to 10 days later (see labels)	Koban WP 35% or Tersan SP WP 65% plus one of these: captan WP 50% Dyrene WP 50% folpet (Phaltan) WP 50% Kromad WP thiram WP 75% zineb WP 75%
Nematodes (many genera and species)	All turfgrasses	Fenamiphos (Nemacur): Apply granules or emulsifiable concentrate, carefully following the manufacturer's directions. Follow nematicide immediately with at least ½ inch of water to ensure that the nematicide penetrates into soil to prevent toxic effects. Treat in fall or spring (or both, if nematodes are a serious problem) when soil temperature is above 55° F. Aerifying turf before application improves results. *Do not apply to newly seeded areas.*	
Slime molds (*Physarum cinereum*, *Fuligo* sp., *Mucilago spongiosa*)	All turfgrasses	May-Sept. Mow, rake, pole, or hose down to remove mold when seen. Controlled by any fungicide listed for *Helminthosporium* diseases.	
Algae, green or black scum	All turfgrasses	Apply when first seen; reapply as needed.	copper sulfate (1 to 2 oz.) Daconil 2787 WP 75% or 6F (4 to 6 oz.) Fore WP 80% (4 to 6 oz.) Tersan LSR WP 80% (4 to 6 oz.) thiram WP 75% (4 to 6 oz.) zineb WP 75% (4 to 6 oz.)
Moss	All turfgrasses	Apply when first seen; reapply as needed.	ferrous ammonium sulfate (16 oz.)

[c] Cleared for use *only* on golf course greens, aprons, and tees by certified golf course superintendents.

1978 Field Crops Weed Control Guide

This guide for using herbicides is based on research results at the University of Illinois Agricultural Experiment Station, other experiment stations, and the U.S. Department of Agriculture. Although not all herbicides commercially available are mentioned, an attempt has been made to include materials that were tested and showed promise for controlling weeds in Illinois. Consideration was given to the soils, crops, and weed problems of the state.

Rainfall, soil type, and method of application influence herbicide effectiveness. Under certain conditions some herbicides may damage crops to which they are applied. In some cases, chemical residues in the soil may damage crops grown later.

When deciding whether to use a herbicide, consider both the risk involved in using the herbicide and the yield losses caused by weeds. If cultivation and good cultural practices are adequate for weed control, you may not need herbicides. Much of the risk can be decreased by heeding these precautions:

- Use herbicides only on approved crops.
- Use recommended amounts. Applying too much herbicide may damage crops, may cause illegal residues, and is costly. Using too little herbicide can result in poor weed control.
- Apply herbicides only at times specified on the label. Observe the recommended intervals between treatment and pasturing or harvesting of crops.
- Wear goggles, rubber gloves, and other protective clothing as suggested by the label.
- Guard against possible injury to nearby susceptible plants, such as soybeans, grapes, and tomatoes. Droplets and vapors from 2,4-D, MCPA, 2,4,5-T, and dicamba sprays may drift several hundred yards. The amine form of 2,4-D is safer to use than the volatile ester form, but even the amine spray may drift to susceptible crops. To reduce the chance of damage, calibrate and operate sprayers at low pressure with tips that deliver large droplets and high gallonage output. Spray only on a calm day or make sure air is not moving toward susceptible crop plants and ornamentals. Some farm liability insurance policies do not cover crop damage caused by dicamba or the ester form of 2,4-D.
- Apply herbicides only when all animals and persons not directly involved in the application have been removed from the area. Avoid unnecessary exposure.
- Properly dispose of empty herbicide containers. Triple rinse and puncture metal containers and haul them to a sanitary landfill. Haul paper containers to a sanitary landfill or burn them. Check label for proper disposal recommendation.
- Return unused herbicides to a safe storage place promptly. Store them in original containers, away from unauthorized persons, particularly children.
- Since manufacturers' formulations and labels are sometimes changed and government regulations modified, always refer to the most recent product label.

This guide is for your information. The University of Illinois and its employees assume no responsibility for results from using herbicides, regardless of whether they are used according to the suggestions, recommendations, or directions of the manufacturer or any governmental agency.

Cultural and Mechanical Control

Plan your weed control program to fit your situation and desires. Most weed control programs combine good cultural practices, mechanical weed control, and herbicide applications. If weeds are not a serious problem, herbicide applications may not be needed.

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Good cultural practices include preparation of a good seedbed, adequate fertilization, seeding on the proper date, use of the optimum row width, and seeding at the rate for optimum stands.

A uniform, weed-free seedbed discourages weed growth and encourages corn and soybean germination. If preplant incorporated herbicides are used, incorporation should be a part of normal seedbed preparation. Excessive preplant tillage may intensify soil crusting.

Planting in relatively warm soils helps soybeans and corn compete better with weeds. Good weed control during the first 3 to 5 weeks is extremely important for both corn and soybeans. If weed control is adequate during that period, corn and soybeans will usually compete quite well with most of the weeds that begin growth later. Optimum row width and plant population also help discourage weed growth.

Narrow rows will shade the centers faster and help the crop compete better with the weeds. There is increased interest in drilling soybeans in narrow rows. Since herbicides alone may not always give adequate weed control, it is often preferable to keep rows wide enough to allow cultivation. However, some of the newer herbicides are improving the chances of adequate control without cultivation.

Early cultivations are most effective when weeds are small. Use the rotary hoe after weed seeds have germinated but before most have emerged. Operate the rotary hoe at 8 to 12 miles per hour and weight it enough to stir the soil and kill the tiny weeds. Rotary hoeing also aids crop emergence if the soil is crusted.

Even though you have used a preemergence or preplant herbicide, if adequate control appears doubtful, use the rotary hoe while weeds are still small enough to be controlled.

Row cultivators also should be used while weeds are small. Throwing soil into the row can help smother small weeds, but be certain not to cover the crop. If a banded herbicide has given adequate weed control in the row, use shields to prevent soil movement into the row during the first cultivation. Cultivate shallow to prevent root pruning. Avoid excessive ridging; it may hinder harvesting and encourage erosion.

Preemergence or preplant herbicides may provide a convenient and economical means of early weed control by allowing delayed and faster cultivation. Herbicides can replace some cultivation, for, unless the soil is crusted, little cultivation is needed where weeds are controlled.

Chemical Weed Control

Plan your chemical weed control program to fit your soil, crops, weed problems, farming operations, and personal desires. Be prepared to modify plans as required during the season. Herbicide performance depends on the weather and on wise selection and application. Your decisions on herbicide use should be based on the nature and seriousness of your weed problem.

Corn or soybeans occasionally may be injured by some of the herbicides registered for use on them. Crop tolerance ratings for various herbicides are given in the table on the last page of this article. Usually the benefits from weed control are much greater than the adverse effects from herbicides. Corn or soybeans under stress from soil crusting, depth of planting, or adverse weather are more subject to herbicide injury. Plants injured by a herbicide are likely to be more subject to disease.

Apply the herbicide at the time specified on the label. Most preemergence herbicides should not be applied after the crop has emerged. Select and apply herbicides at the right rate in order to reduce the risk of crop injury. The application rates for some herbicides vary greatly with soil texture and organic matter.

You also must consider the kinds of weeds likely to be present. The herbicide selectivity table at the end of this guide lists various herbicides and various weeds' susceptibility to them.

Crop planting intentions for the next season also must be considered. Where high rates of atrazine are used, such as to control quackgrass, you should not plant soybeans, small grains, alfalfa, or vegetables the following year. If you are considering planting wheat after soybeans, be sure that the application of Treflan or similar herbicide for soybeans is uniform and sufficiently early to reduce the risk of injury to wheat following soybeans.

Names of Some Herbicides

Trade	Common (generic)
AAtram	atrazine plus propachlor
AAtrex, Atrazine	atrazine
Amiben	chloramben
Amino triazole, Weedazol	amitrole
Amitrol-T, Cytrol	amitrole-T
Banvel	dicamba
Basagran	bentazon
Basalin	fluchloralin
Bladex	cyanazine
Butoxone, Butyrac	2,4-DB
Cobex	dinitramine
Dowpon M, Basfapon	dalapon
Dual	metolachlor
Dyanap, Ancrack, Klean-Krop	naptalam plus dinoseb
Eptam, Eradicane	EPTC
Evik	ametryn
Furloe Chloro IPC	chlorpropham
Igran	terbutryn
Kerb	pronamide
Lasso	alachlor
Lorox	linuron
Maloran	chlorbromuron
Modown	bifenox
Paraquat	paraquat
Premerge-3, Sinox PE	dinoseb
Princep	simazine
Prowl	pendimethalin

Ramrod, Bexton, Propachlor . . . . propachlor
Roundup . . . . glyphosate
Sencor, Lexone . . . . metribuzin
(several) 2,4-D
Sinbar . . . . terbacil
Surflan . . . . oryzalin
Sutan+ . . . . butylate
Tenoran . . . . chloroxuron
Tolban . . . . profluralin
Treflan . . . . trifluralin
Vernam . . . . vernolate

Some herbicides have different formulations and concentrations under the same trade name. No endorsement of any trade name is implied, nor is discrimination against similar products intended.

Where trade names are used in this publication, rates refer to the amount of commercial product. Where common or generic names are used, rates refer to the amount of active ingredient unless a formulation is stated. Unless otherwise stated, rates are given on a broadcast basis.

In this article, the term "registered" refers to registration of the herbicide by the U.S. Environmental Protection Agency and implies EPA review and approval.

Herbicide Combinations

Herbicides often are combined to control more weed species, reduce carryover, or reduce crop injury. Some combinations are sold as a "package mix," while others are tank mixed. Tank mixing allows you to adjust the ratio to fit local weed and soil conditions. Tank mixes should be registered with the EPA, and mixing information should either be on the label of one of the components or appear as supplemental information. If you use a tank mix, you must follow restrictions on all products used in the combination.

Problems sometimes occur when mixing emulsifiable concentrate (EC) formulations with wettable powder (WP) or water dispersible liquid (WDL) formulations. These problems can sometimes be prevented by using proper mixing procedures. Fill the tank at least half full with water or liquid fertilizer before adding herbicides. If using liquid fertilizers, check compatibility in a small lot before mixing a tankful. Wettable powders and WDL's should be added to the tank before EC's. Pre-emulsify EC's by mixing with equal volumes of water before adding them to the tank. Empty and clean spray tanks often to prevent accumulation of material on the sides and the bottom of the tank.

Some of the herbicide combinations that have been registered are listed below. The herbicide listed first is the one that carries label or supplemental instructions on mixing. The other herbicide's label also may carry mixing instructions.

Corn

AAtrex + Princep (PPI, Pre)[1]
Atrazine + propachlor (Pre)
Banvel + atrazine (Post)
Banvel + Lasso (Pre)
Banvel + 2,4-D (Post)
Bladex + atrazine (Pre)
Bladex + Paraquat (NT)
Bladex + Sutan+ (PPI)
Dual + AAtrex (Pre, PPI)
Eradicane + atrazine (PPI)
Eradicane + Bladex (PPI)
Lasso + atrazine (PPI, Pre)
Lasso + Bladex (Pre)
Paraquat + atrazine (NT)
Paraquat + atrazine + Lasso (NT)
Paraquat + atrazine + Princep (NT)
Prowl + atrazine (Pre)
Prowl + Banvel (Pre)
Prowl + Bladex (Pre)
Prowl + Paraquat (NT)
Prowl + Paraquat + Bladex (NT)
Prowl + Paraquat + atrazine (NT)
Roundup + Lasso + atrazine (NT)
Sutan+ + atrazine (PPI)

Soybeans

Amiben + Lasso (Pre)
Amiben + Lorox (Pre)
Cobex + Sencor or Lexone (PPI)
Dyanap + Lasso (Pre)
Furloe + Lasso (Pre)
Lasso + Lorox (Pre)
Lexone or Sencor + Lasso (Pre)
Maloran + Lasso (Pre)
Modown + Lasso (Pre)
Paraquat + Lorox (NT)
Paraquat + Lorox + Lasso (NT)
Paraquat + Sencor (NT)
Paraquat + Sencor + Lasso (NT)
Premerge + Amiben (Pre)
Premerge + Lasso (Pre)
Prowl + Sencor or Lexone (PPI)
Roundup + Lasso + Lorox (NT)
Sencor + Amiben (Pre)
Sencor or Lexone + Treflan (PPI)
Surflan + Dyanap or Klean-Krop (Pre)
Surflan + Lorox (Pre)
Surflan + Lorox + Paraquat (NT)
Surflan + Sencor (Pre)
Surflan + Sencor + Paraquat (NT)
Tolban + Sencor or Lexone (PPI)
Vernam + Treflan (PPI)

[1] PPI = preplant incorporated, Pre = preemergence, Post = postemergence, NT = no-till.

Applying two herbicides at different times is referred to as a sequential or overlay treatment. The user can apply two treatments of the same herbicide (split application), or he can use two different ones, provided such uses are registered. He can apply them at the preplant and preemergence stages or at preemergence and postemergence. One herbicide may be broadcast while the other is banded or directed.

Labeling requirements for sequences are becoming strict. Some products now suggest other herbicides that can be used in sequence with them, while other labels make more general recommendations on sequencing.

Herbicide Incorporation

Some herbicides must be incorporated to reduce surface loss caused by volatilization or photodecomposition. Those which are highly volatile need immediate incorporation. Incorporation of some herbicides may overcome some of the dependence upon rainfall.

Depth and thoroughness of incorporation depend upon type of equipment, depth and speed of operation, soil texture, and soil moisture. It is important to obtain uniform distribution, both horizontal and vertical, to prevent areas of high and low concentrations which may result in injury, residue, or poor control.

Most annual weed seeds germinate in the top 1 or 2 inches of soil; therefore, most of the herbicide should be placed in that area for best results. The tandem disk is the most common implement for incorporation. The disk tends to incorporate herbicides at about half the depth at which the disk is operated. Disking twice may result in more uniform distribution than disking once. The field cultivator has been used for incorporation, but streaking often results unless you use a drag-harrow behind the field cultivator. Disking twice using blades less than 22 inches in diameter or disking followed by field cultivating usually distributes herbicides more evenly than field cultivating twice.

Speed and depth of incorporation are important in obtaining satisfactory results with all equipment. Keep in mind that if the herbicide is incorporated too deep, dilution may reduce its effectiveness.

Herbicides for Corn

Preplant Herbicides

Some herbicides may be applied prior to planting. Some require incorporation, while it is optional for others. Preplant herbicides are usually broadcast, and some may be applied with fluid fertilizer.

Atrazine can be applied within 2 weeks before planting corn, and incorporated to overcome some of the dependence upon rainfall. Incorporation should not be too deep.

Atrazine is very effective for control of many broadleaf weeds. Control of annual grass weeds is often satisfactory. However, atrazine may not adequately control fall panicum, crabgrass, and giant foxtail. See further details under the discussion of preemergence applications for corn.

Sutan+ (butylate) should be incorporated immediately. Where possible, application and incorporation should be done in the same operation.

Sutan+ is registered for field, sweet, and silage corn but not for seed corn production. Sutan+ is primarily for control of annual grass seedlings, but it also can suppress yellow nutsedge. Broadleaf weed control can be improved by combining Sutan+ with atrazine or Bladex, or by following with the application of an appropriate postemergence herbicide.

Sutan+ (6.7E) is used alone at the rate of 3¾ to 7⅓ pints per acre. The higher rates may be used to help control heavy infestations of wild cane and nutsedge and to suppress rhizome johnsongrass. Although Sutan+ contains a "safening agent" to decrease the risk of corn injury, some injury is possible, especially with high rates.

Sutan+ (butylate) plus atrazine can be tank mixed at rates of 1¼ to 2 pounds of atrazine 80W or 1 to 1½ quarts of atrazine 4L plus 3¾ to 4¾ pints of Sutan+ (6.7E) per acre. The higher rate of atrazine is suggested for relatively dark soils. In areas of heavy infestations of wild cane, johnsongrass, or nutsedge, 4¾ to 7⅓ pints of Sutan+ per acre may be used.

Princep (simazine) or Princep plus atrazine may be applied either before or during final seedbed preparation. Best results usually have been obtained when it is applied within 2 weeks prior to planting, although application within 4 weeks may be satisfactory.

Princep improves the control of fall panicum and crabgrass. Princep is less soluble than atrazine and may be more persistent, so follow label precautions to minimize carryover. Princep and atrazine are used in a 1:1 combination, each at half its usual rate for the soil type.

Bladex (cyanazine) plus Sutan+ (butylate) can be tank mixed at the rate of 2 to 2½ pounds of Bladex 80W or 1½ to 2 quarts of Bladex 4L plus 3¾ to 4¾ pints of Sutan+ (6.7E) per acre. The higher rates are for use on medium-to-heavy soils and for the control of wild cane and nutsedge. Incorporate shallowly to reduce the risk of injury.

Eradicane (EPTC) usually gives better control of johnsongrass seedlings, wild cane, and nutsedge than does Sutan+. Eradicane should be preplant broadcast and incorporated immediately. Eradicane may be used on field, sweet, and silage corn, but should not be used on corn grown for seed. The suggested rate is 4¾ to 7⅓ pints per acre within 2 weeks before planting. The higher rate is for heavy infestations of wild cane or nutsedge and suppression of rhizome johnsongrass. High rates, unfavorable growing conditions, or use of certain hybrids may increase the risk of injury. Eradicane can be tank mixed with atrazine or Bladex.

Lasso (alachlor) or Lasso plus atrazine may be used preplant within 7 days before planting corn. A surface application is usually preferred for control of annual grasses, but incorporation may improve nutsedge control. Incorporation of 2½ to 3½ quarts of Lasso 4E per acre can suppress nutsedge. See further details in the preemergence section.

Preemergence Herbicides

Atrazine is available under several names. Corn tolerance is very good with atrazine, which can be used on field, sweet, silage, pop, or seed corn. Atrazine controls annual broadleaf weeds and some annual grasses. Where fall panicum, crabgrass, or giant foxtail are problems, consider using combinations of atrazine with Bladex, Dual, Lasso, or Princep.

Atrazine is formulated as an 80-percent wettable powder and a 4-pound-per-gallon liquid suspension. Rates vary with soil organic matter and texture, weed problems, and whether atrazine is used alone or in combinations. When used alone, rates vary from 2.5 to 5 pounds of atrazine 80W or 2 to 4 quarts of atrazine 4L per acre.

If you use atrazine 80W at more than 3.75 pounds or atrazine 4L at more than 3 quarts per acre, or if you apply after June 10, plant only corn or sorghum the next year. If you use atrazine in the spring, do not plant small grains, small-seeded legumes, or vegetables the next fall or spring. Soybeans planted the year following atrazine may be injured if you had applied more than recommended amounts unevenly, or if you use Sencor or Lexone on the soybeans.

Carryover injury can be minimized by accurate mixing and application, early application, use of the lowest rates consistent with good weed control, use in combinations, and by thorough tillage of the soil before planting subsequent crops. There is usually less risk of atrazine carryover following warm moist seasons than following relatively cool dry seasons like that of 1976. Atrazine carryover is greater on high pH (over 7.5) soils.

Bladex (Cyanazine) does not persist in the soil as long as atrazine, but corn tolerance is better with atrazine than with Bladex. Bladex controls fall panicum and giant foxtail better than atrazine, but control of pigweed and velvetleaf may not be as good (see selectivity table on the last page).

Broadcast rates are 1½ to 5 pounds of Bladex 80W, 1¼ to 4 quarts of Bladex 4L or 8 to 27 pounds of Bladex 15G per acre. Rates should be adjusted for soil texture and organic matter to reduce the possibility of corn injury.

Bladex may be tank mixed with atrazine or Lasso for preemergence use, or with atrazine, Sutan, or Eradicane for preplant use. Since combination rates vary greatly with soil texture and organic matter, refer to the Bladex or other herbicide label for specific rate information.

Ramrod, Bexton, or Propachlor (propachlor) is primarily used on soils with more than 3 percent organic matter. It controls annual grasses and pigweed, but control of most other broadleaf weeds should not be expected. Some farmers band propachlor granules at planting time to control annual grass weeds and then follow with an early postemergence herbicide to control broadleaf weeds.

Corn tolerance to propachlor is good. It is registered for use on field corn, silage corn, sweet corn, and seed corn fields. It is irritating to the skin and eyes, so observe label precautions.

The broadcast rate is 6 to 9 pounds per acre of propachlor 65W or 20 to 30 pounds per acre of propachlor 20G (granules). Use proportionately less for band application.

Propachlor plus atrazine is a combination best adapted to soils with more than 3 percent organic matter. The mixture controls broadleaf weeds better than propachlor alone and controls annual grasses better than atrazine alone. However, velvetleaf may not be controlled.

Propachlor plus atrazine is available as a prepackaged mixture of wettable powder used at the rate of 6 to 8 pounds per acre. For tank mixing, the rate is 4½ pounds of propachlor 65W and 2 pounds of atrazine 80W on soils with more than 3 percent organic matter.

AAtram 20G is a granular combination containing 1 part atrazine and 2 parts propachlor. The rates are 15 pounds per acre broadcast on light soils and 22½ to 30 pounds per acre broadcast on moderately dark to dark soils. Use proportionately less for band applications.

Lasso (alachlor) performs better than propachlor on soils with less than 3 percent organic matter. Lasso may require a little more moisture initially, but weed control may last longer. Lasso is not as irritating to handle as propachlor. However, some individuals may be sensitive, so observe label precautions.

Lasso can control annual grasses and pigweed. Some other broadleaf weeds can be controlled by using an appropriate combination of Lasso and a postemergence herbicide treatment.

The broadcast rate is 2 to 3½ quarts of Lasso 4E or 16 to 26 pounds of Lasso II 15G per acre. Adjust the rate for soil texture and organic matter. Corn does not tolerate Lasso quite as well as it does propachlor; slight injury occasionally has occurred to certain hybrids. Lasso may be used on field, sweet, and silage corn.

Dual (metolachlor) is registered for preplant or preemergence use on field corn (not silage corn) by itself and with AAtrex. Dual is chemically similar to Lasso and controls the same weeds as Lasso, but it may last a little longer to help control late grasses and nutsedge. Corn tolerance appears to be slightly less to Dual than to Lasso. The broadcast rate is 2⅔-4 pints of Dual 6E per acre. Crops other than corn are not to be planted for 18 months under current label restrictions.

Lasso plus atrazine is less irritating to handle and controls fall panicum better than propachlor plus atrazine. Velvetleaf control varies according to reduced rates of atrazine used in the propachlor-plus-atrazine or Lasso-plus-atrazine combinations, but most other broadleaf weeds can be controlled under favorable conditions. Application may be made from immediately after planting until weeds reach the 2-leaf stage and the crop is no more than 5 inches tall (see postemergence section).

Suggested rates for tank mixing are 1½ to 2½ quarts of Lasso and 1¼ to 2 pounds of atrazine 80W per acre, depending upon soil organic matter. See the Lasso label for instructions on making compatibility tests and mixing. Lasso-atrazine 15G granules are used at a broadcast rate of 27 pounds per acre.

Banvel (dicamba) plus Lasso (alachlor) is registered for preemergence use on field corn. Adding Banvel to Lasso improves control of broadleaf weeds without creating risk of carryover injury to crops the following year. However, there is some risk of injury to corn from Banvel applied preemergence, especially if recommended rates are exceeded, applications are not accurate and uniform, or corn is planted too shallow. Do not use on coarse-textured soils or soils low in organic matter. The rate is 1 pint of Banvel plus 2½ quarts of Lasso per acre on fine-textured soils with more than 2½ percent organic matter.

Prowl (pendimethalin) is registered for use on field corn and silage corn. It is available as a 4-pound-per-gallon emulsifiable concentrate for use at rates of 1½ to 2 quarts per acre alone, or 1 to 1½ quarts in combination with atrazine, Bladex, or Banvel. Rates should be adjusted for soil texture and organic matter. It controls annual grasses and gives some control of broadleaf weeds such as pigweed, lambsquarters, smartweed, and velvetleaf. Prowl should be applied only to the soil surface. Do not incorporate for corn since incorporation increases the injury risk considerably.

Postemergence Herbicides

Lasso (alachlor) plus atrazine tank mixture can be applied to emerged corn no more than 5 inches tall. Grass beyond the 2-leaf stage will not be satisfactorily controlled; occasionally some leaf burn may occur. If applied in fluid fertilizer, application must be made before the crop emerges (see preemergence section for further information).

Lasso (alachlor) plus Banvel (dicamba) tank mixture can be used on emerged corn no more than 3 inches tall. Grasses beyond the 2-leaf stage may not be satisfactorily controlled (see preemergence section for further information).

Atrazine can be applied to corn up to 3 weeks after planting but before grass weeds are more than 1½ inches high. Results on grasses more than 1½ inches tall have been rather erratic. Many annual broadleaf seedlings are more susceptible than grass weeds and may be treated until they are up to 4 inches tall. Velvetleaf is sometimes easier to control postemergence than preemergence, especially if reduced rates are used in preemergence combinations.

The addition of nonphytotoxic oils, oil-surfactant mixes, or surfactants has generally increased the effectiveness of postemergence atrazine. The special nonphytotoxic spray oil is used at 1 to 2 gallons per acre. Formulations of 80 percent oil and 20 percent surfactant are used at the rate of 1 to 2 quarts per acre. Some surfactant-spreaders also are marketed for postemergence use with atrazine. These are usually added at 0.5 percent of the total spray volume or about 1 pint per acre. Results with the oils and oil-surfactant mixes have generally been better than those with the surfactants.

Corn has sometimes been damaged from postemergence applications of atrazine and oil. There have been some cases of severe injury where corn has been under stress from prolonged cold, wet weather or other factors.

Do not use more than 2½ pounds of atrazine 80W or 2 quarts of atrazine 4L per acre if you mix with oil. Do not add 2,4-D to the atrazine-oil treatment or severe injury may result. Mix the atrazine with water first and add the oil last. If atrazine is applied after June 10, do not plant any crop except corn or sorghum the next year because of increased risk of herbicide carryover from late application. Refer to the label for other precautions.

Bladex (cyanazine) is registered for postemergence use through the 4-leaf stage of corn growth but before annual grasses exceed 1½ inches in height. The rate is 1½ to 2½ pounds of Bladex 80W in 15 to 30 gallons of spray per acre. (Do not use Bladex 4L.) Injury to corn may occur under cold, adverse growing conditions. The injury may be only temporary yellowing or may be more severe. Corn should not be treated after the 4-leaf stage. Certain agricultural surfactants or vegetable oils may be added to Bladex as specified on the label, but do not use petroleum crop oils for postemergence application.

2,4-D is one of the most economical and effective treatments for controlling many broadleaf weeds in corn. Use drop nozzles if corn is more than 8 inches high to decrease the possibility of injury. If you direct the nozzles toward the row, adjust the spray concentration so that excessive amounts are not applied to the corn.

If you wish to control late-germinating weeds, you can use high-clearance equipment, but do not apply 2,4-D to corn from tasseling to dough stage.

Some corn injury may result from applying 2,4-D. Corn is often brittle for 7 to 10 days after application and thus is susceptible to stalk breakage from high winds or cultivation. Other symptoms of 2,4-D injury are stalk bending or lodging, abnormal brace roots, and failure of leaves to unroll, sometimes called "onion leafing."

Spraying when corn is under stress (cool, wet weather) or when corn is growing very rapidly may increase the possibility of injury. Corn hybrids vary in their sensitivity to 2,4-D, depending upon their genetic makeup.

Apply no more than the recommended rate; this will help avoid corn injury. The suggested broadcast rates of acid equivalent per acre are ⅙ to ¼ pound of ester formulations or ½ pound of amine. This would be ⅓ to ½ pint of ester or 1 pint of amine for formulations with 4 pounds of 2,4-D acid equivalent per gallon.

The ester forms of 2,4-D can vaporize and injure nearby susceptible plants. This vapor movement is more likely with high-volatile than with low-volatile esters. Amine formulations have very low volatility and are less likely to injure nearby susceptible plants. However, spray particles of either the ester or the amine form can drift and cause injury.

Banvel (dicamba) controls smartweed better than 2,4-D. However, Banvel has presented a much more serious problem of injury to soybeans than 2,4-D. Thus, Banvel should be applied before soybeans in the area are 10 inches high. Soybean yields are seldom reduced where slight injury occurs early. However, yields can be reduced when severe injury occurs when soybeans are blooming. Banvel also can affect other susceptible plants, such as vegetables and ornamentals. Use extreme caution to avoid injury to desirable plants from either contaminated sprayers or drift of Banvel from treated areas. Spray thickeners have reduced, but not eliminated, problems with movement of Banvel.

Banvel may be applied until corn is 3 feet high or until 15 days before tasseling. When spraying near soybeans, do not spray corn after it is 2 feet high. If corn is more than 8 inches high, drop nozzles give better weed coverage and reduce drift. If you direct the nozzles toward the row, adjust the spray concentration so that excessive amounts are not applied to the corn. Corn tolerance is relatively good with Banvel; however, corn injury can occur. Broadcast rates are ¼ to ½ pint per acre. Use the higher rate for taller and older weeds.

Do not use Banvel on sweet corn, popcorn, or seed corn. Do not graze or harvest corn for dairy feed before the ensilage (milk) stage.

A mixture of ¼ pint of Banvel plus ½ pint of 2,4-D amine (4 pounds per gallon) per acre is more economical than a full rate of Banvel and may present less risk of corn injury than 2,4-D alone. Banvel K is a commercial mixture of dicamba and 2,4-D amine. Use drop nozzles on corn more than 8 inches high when using a Banvel-plus-2,4-D mixture.

Basagran (bentazon) is registered for use postemergence in corn in a manner similar to that for soybeans (see soybean section). Since corn is quite tolerant of Basagran, there is special interest in its use in seed corn production fields.

Directed Postemergence Herbicides

Directed sprays are sometimes needed for emergency situations, especially when grass weeds become too tall for control with cultivation. However, weeds are often too large for directed sprays to be very practical by the time help is sought. Place primary emphasis on early control measures, such as use of preemergence herbicides, rotary hoeing, and timely cultivation.

Directed sprays cannot be used on small corn, and a height difference between corn and weeds is usually needed to keep the spray off the corn. Corn leaves that come into contact with the spray can be killed, and injury may affect yields.

Lorox (linuron) may be applied as a directed spray after corn is at least 15 inches high (free standing) but before weeds are 8 inches tall (preferably not more than 5 inches). This height difference occurs in few fields and lasts only a few days. Lorox can control both grass and broadleaf weeds.

The broadcast rate is 1¼ to 3 pounds of Lorox 50W per acre, with the lower rates suggested for use on small weeds and lighter soil types. Add Surfactant WK at the rate of 1 pint per 25 gallons of spray mixture. Cover the weeds with the spray, but keep it off the corn as much as possible. *Consider this an emergency treatment.*

Evik 80W (ametryn) is registered for directed use when corn is more than 12 inches tall and weeds are less than 6 inches tall. The rate is 2 to 2½ pounds Evik 80W per acre (broadcast) plus 2 quarts of surfactant per 100 gallons of spray mixture. Extreme care is necessary to keep the spray from contacting the leaves. Injury to corn is possible, so *use only as an emergency treatment.* To avoid possible yield reduction, Evik should not be applied within 3 weeks of tasseling.

No-Till Corn

No-till (zero-till) corn puts chemical weed control to a real test. You must control both vegetation existing at planting and weed seedlings that begin growing after planting. Existing vegetation may be a perennial grass sod, a legume or legume-grass sod, an annual cover crop, or weeds that began growing before planting.

Paraquat (1 to 2 pints per acre) plus atrazine 80W (2½ to 3¾ pounds per acre) is the most common herbicide treatment used in no-till corn. The Paraquat has a contact action, while the atrazine provides both pre- and postemergence control. Use 40 to 60 gallons of spray per acre for fescue and clover sod. For corn or soybean stubble, 20 to 30 gallons of spray per acre may be adequate. Add a nonionic surfactant, such as Ortho X-77, at ½ pint per 100 gallons of diluted spray.

A pretreatment with 2,4-D or Banvel can improve control of broadleaf perennials, such as alfalfa. For no-till corn a good grass herbicide is usually necessary. For control of fall panicum and crabgrass, a mixture of Lasso plus atrazine or atrazine plus simazine may give better control than atrazine alone. The rate for Lasso plus atrazine is 1½ to 2 quarts of Lasso plus 1½ to 2 pounds of atrazine 80W per acre. The rate for atrazine plus simazine is 1¼ to 2 pounds of atrazine 80W plus 1¼ to 2 pounds of simazine 80W per acre. Bladex, Prowl, Prowl plus atrazine, and Prowl plus Bladex also are registered for use in combination with Paraquat for no-till corn. Roundup plus Lasso plus atrazine, also cleared for no-till, may be useful where certain perennials are a problem.

Herbicides for Soybeans

You must consider the kinds of weeds likely to be present when you select preplant and preemergence herbicides for soybeans. The herbicide selectivity table on the last page lists various herbicides and their relative control of various weeds.

Soybeans occasionally may be injured by the herbicides registered for use on them. Fortunately, soybeans usually can outgrow modest amounts of early injury with little or no effect on yield. Use high-quality seed of disease-resistant varieties and do not plant too deep. However, planting too shallow may place the seed too near preemergence herbicides such as Sencor, Lexone, Lorox, or Maloran and result in excessive herbicide injury to soybean seedlings. Soybeans injured by a herbicide are likely to be more subject to disease.

Preplant Herbicides

Herbicides can be incorporated with various implements, but the one most commonly used in Illinois is the tandem disk. Disking twice in different directions may distribute the herbicide more uniformly. The second incorporation, whether with disk or field cultivator, should not be deeper than the first. Streaking may result from using the field cultivator unless soil is in good tilth and the equipment is operated correctly.

See the earlier section on herbicide incorporation and the product label for further information on incorporation of preplant herbicides.

Dinitroaniline herbicides. There are five related dinitroaniline herbicides registered for incorporation prior to planting soybeans — Basalin, Cobex, Prowl, Tolban, and Treflan. The rates, time of application, and length of time between application and incorporation vary for the different products. Weed control, persistence in the soil, and soybean tolerance are quite similar when recommended rates are used. These products can control annual grasses, including wild cane and johnsongrass seedlings. They usually control pigweed and lambsquarters and may provide some control of smartweed and annual morningglory. Control of most other broadleaf weeds usually requires combinations or sequential treatments with other herbicides.

Soybeans sometimes are injured by preplant dinitroaniline herbicides. Injured plants may be stunted with swollen hypocotyls and inhibited lateral roots. Injury is not usually considered serious, but it may be significant under cool, wet conditions where other factors, such as seedling diseases, also affect the plants. When applied to the soil surface, Prowl may sometimes cause stem callous at ground level, especially if herbicide concentration is excessive. This can lead to soybean lodging.

Although similar, persistence in the soil varies with the different dinitroaniline herbicides. Cobex has the shortest persistence, while Treflan has the longest. Tolban and Basalin persist about as long as Treflan. Corn, sorghum, or small grains that follow a dinitroaniline herbicide may be injured if excessive rates were used, the application was made relatively late in the season, application was not uniform, or the previous growing season was too dry and cool. Use no more than the recommended rate and apply the herbicide uniformly. Using the reduced rates of dinitroaniline herbicides that are specified in some approved combinations also may decrease the possibility of residue problems the next season.

Carryover injury has been greater when the chisel plow, field cultivator, or disk has been used instead of the moldboard plow. The more thorough tillage methods tend to dilute the herbicide and thus reduce risk of injury from herbicide residue. Reduced tillage methods have some advantages, but where conditions suggest increased risk from herbicide residue and where erosion risks are not too great, consider more thorough tillage for that season.

Treflan (trifluralin) can be applied alone anytime in the spring before planting, but it should be incorporated into the soil within 8 hours of application.

The rate is 1 to 2 pints of Treflan 4E per acre. Use 2 pints on silty clay loam or clay loam soils with more than 4 percent organic matter. Treflan is also available as a 5-percent granule.

Cobex (dinitramine) controls the same weeds as Treflan, but soybean tolerance is not as good. Soybeans under stress from disease, deep planting, or cold, wet weather may be more susceptible to injury. The suggested rates are ⅔ to 1⅓ quarts of Cobex 2E per acre. Cobex incorporation should be shallow but thorough, and should be within 24 hours after application.

Tolban (profluralin) has crop tolerance and persistence equivalent to that of Treflan when rates are adjusted to give equivalent control of weeds. The higher rate may give morningglory suppression on soils with less than 3 percent organic matter. Rates are 1 to 3 pints of Tolban 4E per acre. Tolban should be incorporated within 4 hours after application.

Prowl (pendimethalin) may be applied within 60 days before planting and should be thoroughly incorporated within 7 days. With enough rain, incorporation may not be necessary. Prowl controls the same weeds as

Treflan but may also reduce competition from velvetleaf. The suggested rate is 1 to 3 pints of Prowl 4E per acre.

Basalin (fluchloralin) can be applied within 8 weeks before planting. It should be incorporated within 8 hours of application. Rates are 1 to 3 pints of Basalin 4E per acre. Weed control is similar to that obtained from Treflan.

Sencor and Lexone (metribuzin) are cleared for preplant incorporation with some dinitroaniline herbicides. The rate is usually ½ to 1 pound of Sencor or Lexone 50W or ½ to 1 pint of 4L per acre in these combinations. When used in this manner, metribuzin should usually be applied within 10 days of planting, and incorporation should be relatively shallow but thorough.

Vernam (vernolate) controls annual grasses and pigweed. Control of annual morningglory, velvetleaf, and yellow nutsedge is sometimes fair. Some soybean injury may occur in the form of delayed emergence, stunting, and leaf crinkling. Injury is usually temporary and usually is not reflected in yields. Vernam can be applied within 10 days prior to planting. Incorporate immediately to prevent surface loss. The broadcast rate is 2⅓ to 3½ pints of Vernam 7E or 20 to 30 pounds of Vernam 10G per acre.

Vernam plus Treflan is a tank mix combination with a reduced rate of Vernam. This may decrease the risk of soybean injury, but it may also decrease control of velvetleaf and yellow nutsedge. The rate is 1 pint of Treflan 4E plus 2⅓ to 3 pints of Vernam 7E per acre.

Lasso (alachlor) can be preplant incorporated at rates of 2½ to 3½ quarts per acre for suppression of nutsedge. Apply within 7 days before planting and do not incorporate too deeply. Preemergence application is usually preferred for control of annual grasses.

Preemergence Herbicides

Amiben (chloramben) controls many annual grass and broadleaf weeds in soybeans. Do not expect control of annual morningglory or of cocklebur. Control of velvetleaf and jimsonweed may be erratic. Amiben occasionally injures soybeans, but damage is usually not severe. Injury appears as malformed roots and stunted plants.

The recommended broadcast rate is 1 to 1½ gallons of Amiben 2S or 20 to 30 pounds of Amiben 10G per acre. The lower rate often may not provide adequate weed control. If it does not rain within 3 to 5 days, you should rotary hoe or harrow. A tank mix of Amiben at 1 gallon per acre plus Lasso at 2 quarts per acre is registered and may improve consistency of performance.

Lorox (linuron) is best adapted to silt loam soils that contain less than 2 to 3 percent organic matter. It is not generally recommended for use alone on soils with more than 4 percent organic matter. Although the margin of safety between dependable weed control and crop damage is rather narrow, accurate and uniform application can reduce the possibility of crop injury. Rates must be adjusted accurately for soil texture and organic matter. Lorox can control a broad spectrum of weeds, but broadleaf weeds are usually controlled better than grass weeds. Annual morningglory is not controlled, and control of cocklebur is variable. Lorox is often used in a mixture with Lasso or sometimes as an overlay treatment after Treflan.

Maloran (chlorbromuron) is similar to Lorox, but requires higher rates for equivalent control. Usually about 1½ times as much Maloran as Lorox is required. When rates are adjusted to give about the same degree of weed control from both products, then crop tolerance is also similar.

The rate alone is 2 to 8 pounds of Maloran 50W per acre. Maloran is registered for use with Lasso to improve grass control and minimize soybean injury. Rates for the Maloran-Lasso combination are 1½ to 4½ pounds of Maloran 50W with 1½ to 2½ quarts of Lasso per acre.

Lasso (alachlor) controls annual grasses plus pigweed. Lasso will also suppress nutsedge when incorporated preplant at higher rates (see preplant section). Preemergence application is usually preferred for annual grass control. The broadcast rate is 2 to 3½ quarts of Lasso 4E or 16 to 26 pounds of Lasso II 15G per acre. Soybean seedlings often show a crinkling and drawstring effect on the first to second trifoliolate leaves, but these symptoms should not cause concern.

Lasso plus Lorox gives better broadleaf control than Lasso alone, and better grass control than Lorox alone. Reducing the Lorox rate reduces but does not eliminate the risk of soybean injury. Select the rate carefully to reduce the risk of injury but to maintain control of velvetleaf and jimsonweed.

The broadcast rate is 1½ to 3 quarts of Lasso 4E plus 1 to 3 pounds of Lorox 50W. Rates must be adjusted to soil texture and organic matter. On silt loam soils with less than 3 percent organic matter, such as occur in southern Illinois, the common rate is 1½ to 2 quarts of Lasso 4E plus 1 to 1½ pounds of Lorox 50W.

Sencor or Lexone (metribuzin) usually controls most annual broadleaf weeds except annual morningglory. Control of giant ragweed, jimsonweed, and cocklebur may be marginal, and annual grass control is marginal to erratic at rates needed to minimize injury.

The margin of safety between dependable weed control and crop damage is rather narrow. Stress caused by cold, wet weather, soybean seedling diseases, depth of planting, or injury from other herbicides may increase the possibility of soybean injury from Sencor or Lexone. Planting soybeans about 1½ inches deep may help reduce the risk of herbicide injury.

Adjust rates accurately for soil conditions and *do not apply to sandy soils.* The suggested label rate alone is ¾ to 1½ pounds of Sencor 50W or ¾ to 1 pound of Lexone

50W per acre. Sencor or Lexone may be tank mixed with some preplant herbicides such as Treflan, Tolban, Prowl, or Cobex, or used preemergence following preplant incorporation of some herbicides.

Sencor or Lexone plus Lasso is a preemergence combination to improve grass control and decrease risk of soybean injury. Adjust Sencor or Lexone rates carefully to soil texture and organic matter. The rates for this combination vary somewhat on the three different labels but are ¾ to 1 pound of Sencor or Lexone 50W plus 1½ to 2½ quarts of Lasso 4E on most Illinois soils. Accurate, uniform application is essential in order to minimize risk of soybean injury.

Surflan (oryzalin) is a preemergence dinitroaniline herbicide for soybeans grown on soils with less than 3 percent organic matter. Surflan can control annual grasses, pigweed, and lambsquarters if adequate rain occurs. If ½ inch of rain does not fall within seven days after application, you should rotary hoe to control emerging weeds.

Furloe Chloro-IPC (chlorpropham) can be used to control smartweed. A broadcast rate of 2 to 3 quarts of Furloe 4E per acre is suggested. A tank mix with Lasso is registered for preemergence use. Furloe is also registered for preemergence surface application after preplant application of Treflan.

Modown (bifenox) controls smartweed, jimsonweed, and velvetleaf, but does not provide good control of annual morningglory, cocklebur, and annual grasses. It is approved as a sequential treatment over Treflan and as a tank mix with Lasso to improve annual grass control. Soybeans may show stunting and crinkling from Modown. This injury lasts only a few weeks and usually has not caused yield reductions.

The rate alone or over Treflan is 2 to 2½ pounds of Modown 80W per acre. The tank-mix rate with Lasso is 1½ to 2 pounds of Modown 80W plus 2 to 2½ quarts of Lasso per acre.

Dyanap (dinoseb plus naptalam) can be applied to soybeans from planting until the unifoliolate leaves of the seedling unfold and expose the growing point. Weed control from preemergence applications has been rather variable. Control of broadleaf weeds is better than control of grasses. A tank mix of Dyanap plus Lasso or Surflan is registered to improve grass control.

Ancrak and Klean-Krop are other trade names for the formulated mixture of dinoseb plus naptalam. However, they are not registered in combination with Lasso or for postemergence application. Klean-Krop is registered for preemergence use with Surflan.

Premerge-3 (dinoseb) is registered for tank mixing with Lasso or Amiben for preemergence use until soybeans begin to emerge (cracking stage). See the postemergence section for further information on dinoseb.

Postemergence Herbicides

The postemergence use of herbicides for soybeans has not been very popular in Illinois. Most postemergence herbicides for soybeans do not control annual grasses, and their use for broadleaf weeds is too often an emergency or "rescue" treatment. Soybeans are injured by some of the herbicides available for postemergence use. If there is a height difference between soybeans and weeds, the amount of soybean injury can be decreased by directing the spray toward the weeds while minimizing the spray's contact with the soybeans.

Dinoseb water-soluble salts are sold under several trade names, including Premerge and Sinox PE. Dinoseb is registered for early postemergence use when soybeans are still in the cotyledon stage. Do not apply if the first leaves have opened and exposed the terminal bud. Do not apply if the soil surface is moist.

Dinoseb is primarily a contact herbicide that controls broadleaf weeds. It does not control annual grasses very well and gives very little residual control of seedlings germinating after application. It is registered for tank mixing with Lasso for early postemergence use to improve grass control. Dinoseb also is registered for directed postemergence treatment from the time soybeans are 5 to 6-inches high until they begin to bloom.

The postemergence rates for dinoseb vary with air temperature, formulation, and type of application (see label). Do not apply if the air temperature is more than 90° F. *Caution: Dinoseb is quite toxic to man and animals. Exercise extreme caution when using this material.*

Dinoseb also is registered as a salvage treatment over the tops of soybeans after true leaves have unfolded and until soybeans begin to bloom. This treatment is for use where infestations of weeds such as cocklebur or annual morningglory are so serious that treatment is the only alternative to replanting. Crop injury is likely and the grower assumes the risk. The rate is 1 to 2 pints per acre. Do not use surfactant. You may need additional postemergence treatments for satisfactory weed control.

Tenoran (chloroxuron) can be applied from the time trifoliolate soybean leaves form until broadleaf weeds are 1 to 2 inches tall. It is primarily for control of annual broadleaf weeds in soybeans. Weed control with chloroxuron has been somewhat erratic, and soybeans usually show some injury. However, this early season injury has not usually reduced yields.

The broadcast rate is 2 to 3 pounds per acre of Tenoran 50W plus 1 pint of an approved compatible surfactant per 25 gallons of spray. Use proportionately less for directed or semidirected sprays. A nonphytotoxic oil can be used at 1 gallon per acre instead of the surfactant with the directed or semidirected sprays.

Basagran (bentazon) can control many broadleaf weeds, such as cocklebur, jimsonweed, and velvetleaf. It is weak on pigweed, lambsquarters, and annual morningglory. It can provide some control of yellow nutsedge, but not of annual grasses. If annual grasses are a problem, it will be necessary to use a preplant or preemergence herbicide prior to using Basagran.

The suggested rate for Basagran is ¾ to 1½ quarts per acre, depending on weed size and species. Application should be done when weeds are small (2-3 inches) and actively growing. Spraying during warm sunny weather can also improve performance. Use 20 to 40 gallons of water per acre in order to get complete weed coverage. Commonly grown soybean varieties generally have shown relatively good tolerance to Basagran. Adding a surfactant to Basagran may increase performance, but may also increase the chance of soybean injury.

Dyanap (dinoseb plus naptalam) can be applied to soybeans after the second trifoliolate leaf opens and until beans become 20 inches tall. Weeds should be less than 6 inches tall (less than 3 inches tall is preferable) for most effective control. Two to 3 quarts per acre is recommended for control of cocklebur, jimsonweed, smartweed, and annual morningglory less than 3 inches tall. Four quarts per acre may control cocklebur and jimsonweed taller than 3 inches, but do not expect control of most other species at that size.

Best results are obtained by using high pressure (60 to 70 pounds per square inch) and 8 to 10 gallons of water per acre. Since this procedure will cause spray particles to be small, try to minimize drift. Do not apply Dyanap to wet soybean foliage. Soybean leaf burn can occur with postemergence applications, but the crop usually recovers within 2 to 3 weeks with little yield loss.

Butoxone SB and Butyrac (2,4-DB) are amine formulations for postemergence control of cocklebur in soybeans. 2,4-DB also may give some control of annual morningglory and giant ragweed. It can be applied broadcast over the top from 10 days before soybeans begin to bloom until midbloom, but expect some soybean injury. Injury symptoms include leaf wilting, stem curvature, and cracking of stems. Lodging may be increased and, if excessive rates are used or if unfavorable conditions exist, yields may be reduced. Consider 2,4-DB for emergency control of cocklebur when potential benefit from weed control is more significant than risk of soybean injury.

Directed sprays may reduce severity of injury. 2,4-DB can be directed when soybeans are at least 8 inches high and cockleburs are less than 3 inches high. Do not spray on more than the lower third of the soybean plant. Do not apply if soybeans show symptoms of Phytophthora root rot disease or are under drouth stress.

Butyrac 200 plus Lorox (tank mix) and Paraquat (alone) also are registered for directed postemergence treatment in soybeans to control certain weeds. However, they have not been used much in Illinois. Soybeans must be at least 8 inches tall and weeds not more than 2 inches tall. Nozzles must be adjusted to spray only the lower third of the soybean plant to avoid serious soybean injury. Read the product labels for the correct rates and precautions.

Double-Crop and No-Till Soybeans

Soybeans are sometimes produced without seedbed preparation either in last year's crop residues (no-till) or as a second crop after harvesting soybeans (double-crop). The no-till concept of planting soybeans in wheat stubble has greatly improved the probability of success of double-cropping by conserving moisture and time.

Existing weeds or vegetation must be "knocked down" with a herbicide such as Paraquat or Roundup. One to 2 pints of Paraquat per acre plus a nonionic surfactant such as Ortho X-77 at 8 ounces per 100 gallons of diluted spray is suggested. Use the higher volumes of water suggested on the label if weeds are more than 6 inches tall. Control of fall panicum and smartweed has been erratic with Paraquat.

Preemergence herbicides registered as tank mixes with Paraquat are Lorox, Lasso plus Lorox, Sencor, Sencor plus Lasso, Surflan plus Lorox, and Surflan plus Sencor or Lexone. Lasso plus Lorox is also registered as a tank mix with Roundup. Roundup is used where fall panicum or johnsongrass are problems. (No-till is not recommended if johnsongrass or other perennial weeds are serious problems.)

Dow General plus diesel fuel is labeled as a "knockdown" herbicide for no-till soybeans planted in wheat stubble. Results vary considerably with temperature.

Paraquat Harvest Aid

Paraquat is registered for drying weeds in soybeans. It may be applied when beans are fully developed and when at least half of the leaves have dropped and the rest are turning yellow. If applied before beans are fully developed, yield reductions can result. Do not apply unless beans are ready to withstand frost.

The recommended broadcast rate is ½ to 1 pint per acre. The higher rate is for cocklebur. Use the suggested rate in 20 to 40 gallons of spray per acre for ground application or in 2 to 5 gallons per acre for aerial application. Add 1 quart of Ortho X-77 or similar surfactant per 100 gallons of spray. Do not pasture livestock within 15 days of treatment, and remove livestock from treated fields at least 30 days before slaughter.

Herbicides for Sorghum

Sorghum acreage is not large in Illinois. However, some is grown in southern Illinois and in bottomlands where weed problems are severe. Because of small acreages, most dealers do not stock specialty sorghum herbicides, so herbicides registered for use with both corn and sorghum often are used.

Atrazine may be used for weed control in sorghum (grain and forage types) or sorghum-sudan hybrids. Application may be made preplant, preemergence, or postemergence. Sorghum tolerates postemergence application better than earlier applications. Injury may occur from preplant or preemergence applications when sorghum is under stress from unusual soil or weather conditions or when rates are too high. The rate of application for preplant and preemergence is 2 to 3 pounds of atrazine 80W per acre. The postemergence rate is 2½ to 3¾ pounds per acre. Follow rates and precautions on the product label carefully. Rotational crop recommendations and weed control are the same as for atrazine used in corn. Failure to control fall panicum has been one of the big problems.

Ramrod, Bexton, or Propachlor (propachlor) may be used alone or in combination with atrazine or Bladex for sorghum. Propachlor will improve grass control, but rates must not be skimpy, especially on soils relatively low in organic matter. For specific rates, consult the product label.

Igran (terbutryn) may be applied alone or in tank-mix combination with atrazine 80W or Milogard 80W, but the combinations are recommended. Heed all label precautions. Winter wheat can follow 4 months after sorghum has been treated with Igran alone. Combinations of Igran with atrazine or Milogard have the same rotational restrictions as either atrazine or Milogard alone.

Milogard (propazine) has better sorghum tolerance than either atrazine or Igran, but grass control is not as good. Only corn or sorghum may be planted in rotation within 12 months after treatment. Other crops in rotation have an 18-month restriction following treatment of sorghum with Milogard. Rates are 2½ to 3 pounds of Milogard 80W per acre.

Bladex (cyanazine) is registered for preemergence use on grain sorghum only in combination with propachlor. Sorghum tolerance is inadequate for using Bladex alone. The Bladex label has rates and precautions.

2,4-D may be applied postemergence for broadleaf control in 4- to 12-inch tall sorghum. Use drop nozzles if sorghum is more than 8 inches tall. Rates are similar to those for use in corn.

Banvel (dicamba) is registered for postemergence use in sorghum to control broadleaf weeds. Sorghum tolerance is fair. However, since sorghum often is ready for postemergence treatment when soybeans are beginning to bloom, potential drift damage to soybeans is great. An application of ½ pint can be made within 10 to 25 days after sorghum emerges. Earlier or later treatment can cause serious injury to sorghum.

Herbicides for Small Grains

Small grains seeded in the fall or early spring often compete very well with most weeds if the stand is good and a good fertilization program is followed. Herbicide suggestions for small grains underseeded with a legume differ from those for small grains growing alone. If wild garlic is a problem, do not underseed with a legume; see the weed section for herbicide suggestions.

2,4-D is used to control certain broadleaf weeds. Winter wheat is more tolerant to 2,4-D than oats, but do not spray wheat in the fall. Small grains can be sprayed in the spring after the grain (wheat or oats) has fully tillered but before it begins rapid stem elongation. Spraying in the boot stage may injure the crop and reduce yield. If the small grain is underseeded with a legume, use only the amine formulation of 2,4-D. Follow rate suggestions accurately in order to minimize possible injury. Ester formulations may be used where there are no legume underseedings and are suggested for control of wild garlic (see special weed section).

MCPA is less likely to damage oats and legume underseedings than 2,4-D, but it is more expensive and will not control as many different weed species. For small grains underseeded with a legume, use ¼ pound per acre (active ingredient) when the small grain is between the tiller and boot stages and when legumes are 2 to 3 inches tall.

Banvel (dicamba) should not be used on small grains that have a legume underseeding. It will control wild buckwheat and smartweed better than 2,4-D but is poorer for controlling mustards. It may be used alone or in combination with 2,4-D. Banvel K is a formulated mixture of dicamba and 2,4-D amine. Banvel should be applied after winter wheat has fully tillered and before it begins to joint (nodes begin to form in the stem). Do not apply later or lodging and yield reductions can occur. The rate is ¼ pint of Banvel alone or with 4 to 6 ounces of 2,4-D (active ingredient) per acre.

Small Grain Stubble Fields

Stubble fields of small grains that have not been underseeded with a legume or double-cropped often are neglected and become infested with weeds after harvest. These weeds may not present an immediate economic problem to the grower, but they do supply weed seeds to affect future crops. Tillage can be used to control weeds in stubble fields but may subject the land to erosion. Mowing may control some weeds, but many species grow back rapidly.

Chemical control can often be quite effective and economical, while leaving some crop residue for soil protection. In small grain stubble not underseeded with legumes, most broadleaf weeds can be controlled with 2,4-D, and dalapon can control many grasses. Rates may be varied depending on the kind and size of weeds present. Usually ¼ to 1 pound of 2,4-D and 3 to 7 pounds of dalapon are adequate. Weeds should be treated when actively growing. Be sure to follow label directions carefully.

Herbicides for Forage Crops

Weed control in alfalfa and clovers differs according to crop species and type of seeding — crop alone (pure seeding) or in combination with a grass species. Be sure to consult the label for proper use. Alfalfa and most clovers can be established without a companion crop and where there is not a forage grass-legume mixture by using Eptam or Balan.

Eptam 7E (EPTC) may be applied at a rate of 3½ to 4½ pints per acre and incorporated just before planting. It is most effective on grasses and also can give some control of nutsedge, especially at the higher rates.

Balan (benefin), used preplant, is incorporated at a rate of 3 to 4 quarts per acre and applied up to 10 weeks before planting. The rate varies with soil type. Balan will control many annual grasses and some broadleaf weeds.

Butoxone or Butyrac (2,4-DB) can be used postemergence to control broadleaf weeds in alfalfa and most clovers after the companion crop is removed or in legume-only or legume-grass seedings established without a companion crop. Rates are 1 to 2 quarts per acre of ester formulations or 1 to 3 quarts of the amine formulation. Ester formulations may be used on alfalfa and birdsfoot trefoil, but do not use them on most clovers. Do not graze livestock on or cut hay from treated fields within 30 days after treatment.

Princep (simazine) can be applied to pure alfalfa stands established more than 12 months. Apply after the last cutting in the fall but before the ground is permanently frozen. Do not apply to alfalfa covered with snow. Princep applied to alfalfa-forage grass mixtures can kill the forage grass. Princep can control many grasses and broadleaf weeds but will not control most well-established perennial or biennial weeds. Rates are 1 to 1½ pounds per acre, depending on soil type. If excessive rates are used, applications are made at the wrong time, or unfavorable conditions exist, crop injury can occur.

Kerb (pronamide) can be applied to either newly seeded or established alfalfa during the fall or winter while the alfalfa is dormant. Fall application is considered best for most weeds. Pronamide will control most annual grass and broadleaf weeds and help suppress quackgrass. Do not apply to mixed stands of alfalfa and forage grasses. Rates vary with weeds and soils. Do not graze or harvest for forage within 120 days of treatment.

Sinbar (terbacil) can be applied to pure stands of alfalfa that are at least a year old. It controls many annual grasses and broadleaf weeds. Apply ½ to 1½ pounds per acre when alfalfa is dormant (fall or spring) but not when the ground is frozen. Injury may result when it is used on certain types of soil or under unfavorable growing conditions.

Furloe Chloro IPC (chlorpropham) may be applied to active, semidormant, or dormant alfalfa that is established or to newly seeded alfalfa with three or more trifoliolate leaves. Application for control of chickweed and downy brome may be made from October through January using 1 to 2 quarts of the 4 EC. After the beginning of February, 2 to 3 quarts can be used. The rate for granules is 40 pounds per acre of the 10 G. Do not apply within 40 days of harvest. Do not apply to alfalfa-grass mixtures.

Premerge-3 (dinoseb) can be used for chickweed control in pure stands of alfalfa and clover. Rates are 1½ to 2 quarts per acre for new stands and 1 to 1½ quarts per acre for established stands. Repeat applications may be needed for weeds that emerge after treatment or for heavy infestations. Do not graze or feed treated forages to livestock within 6 weeks of application. *Caution: Dinoseb is quite toxic to man and animals.*

Herbicides for Grass Pastures

Pasture weed control must be part of a total program of good management that includes proper grazing, good fertilization, and reseeding as necessary.

2,4-D at ½ to 1 pound per acre should provide adequate control of most broadleaf weeds. Higher rates may be needed for more resistant weeds and some perennials. Milk cows should not be grazed on treated land for 7 days after treatment.

2,4,5-T is more effective than 2,4-D on woody plants. It may be used alone or in combination with 2,4-D. Do not graze dairy cows on lands treated with 2,4,5-T for 6 weeks. Meat animals should not graze on pastures recently treated with 2,4,5-T within 2 weeks of slaughter. It is illegal to spray 2,4,5-T on ditchbanks, lakes, ponds, or around homes.

Kuron 2,4,5-TP (silvex) will control most woody plants about as effectively as 2,4,5-T and does not have the same area restrictions. However, you should observe the same grazing restrictions as with 2,4,5-T.

Banvel (dicamba) can control many broadleaf weeds when used at a rate of 1 to 4 pints per acre. Delay grazing 7 to 40 days and delay harvest 37 to 70 days, depending on the amount applied. Do not use where desirable legumes are present; they can be killed by this rate of Banvel. Take precautions to avoid injury to other nearby plants that are susceptible to Banvel.

Specific Weed Problems

Yellow Nutsedge

Yellow nutsedge is a perennial sedge and differs from grass in that it has a triangular stem. It can reproduce by seed, but it mainly reproduces by tubers. Regardless of the soil depth at which the tuber germinates, a basal bulb develops 1 to 2 inches under the soil surface. A complex system of rhizomes (underground stems) and tubers develops from this basal bulb. For the most effective control, soil-applied herbicides should be incorporated into the same soil layer in which this basal bulb is developing. Yellow nutsedge tubers begin sprouting about May 1 in central Illinois.

For soybeans, a delay in planting until late May allows time for two or three tillage operations to destroy many nutsedge sprouts. Tillage helps deplete food reserves in nutsedge tubers. Row cultivation is helpful. Preplant applications of Lasso or Vernam also will help.

Lasso (alachlor) applied preplant incorporated at 2½ to 3½ quarts per acre (½ quart more than for surface-applied rates) often gives good control of nutsedge.

Vernam 7E (vernolate) applied preplant at 3½ pints per acre is also effective against yellow nutsedge. Immediate incorporation is necessary with Vernam.

Basagran (bentazon) is a postemergence treatment that also can help control nutsedge in soybeans. One quart per acre can be applied when nutsedge is small. A split application (two treatments) of Basagran also has been registered. For improved control, use preplant treatments and good tillage in addition to Basagran.

For corn, early preplant tillage before nutsedge sprouts is of little help for controlling nutsedge. Timely cultivation is helpful in corn, but a program of herbicide plus cultivation has provided the most effective control of nutsedge.

Several preplant treatments are available. **Eradicane (EPTC)** at 4¾ pints per acre is effective for control of yellow nutsedge in corn. It must be incorporated immediately. **Lasso,** preplant incorporated as for soybeans, also can be quite effective. **Sutan+** may suppress nutsedge, but it usually is not as effective as Eradicane. Relatively high rates of **atrazine** sometimes give relatively good control of nutsedge, but the results have been somewhat variable. The combinations of Lasso or Sutan+ incorporated with atrazine may give some control of nutsedge while also controlling many other broadleaf weeds and grasses.

Dual (metolachlor) can be applied preplant incorporated, or preemergence alone or in combination with atrazine for nutsedge control in corn. Rates of Dual 6E are 2⅔ to 4 pints per acre when used alone.

Atrazine or Bladex (cyanazine) as postemergence sprays are used to control emerged yellow nutsedge when it is small. However, their performance has been somewhat erratic. Split applications of atrazine plus oil have been more effective than single applications. **Lorox (linuron)** directed postemergence spray also has given some control. **Basagran** can be used in corn in a manner similar to that for soybeans.

Johnsongrass

Johnsongrass is found primarily in the southern third of Illinois. It is often a serious problem where infestations occur. It is a perennial and can reproduce both from seeds and by rhizomes. Several herbicides can control seedlings, but the control of johnsongrass rhizomes should involve both chemical and cultural methods.

Much of the rhizome growth occurs after the johnsongrass head begins to appear. Mowing, grazing, or cultivating to keep the grass less than 12 inches tall can reduce rhizome production significantly.

Control of johnsongrass also can be improved with tillage. Fall plowing and disking bring the rhizomes to the soil surface, where many of them are winter-killed. Disking also cuts the rhizomes into small pieces, making them more susceptible to chemical control.

Johnsongrass rhizomes can be controlled or suppressed using certain herbicides in various cropping programs. Several preplant incorporated herbicides can provide control of johnsongrass seedlings in soybeans or corn (see the table at the end of this article).

Treflan (trifluralin) or Tolban (profluralin) used in a three-year soybean program has been fairly successful in controlling rhizome johnsongrass. Treflan or Tolban are used at twice the normal rate each year for two years, and then either at the normal rate or another suitable herbicide is used the third year before resuming a regular cropping sequence. Research results suggest that control may be 25 to 50 percent the first year and about 75 percent the second year. Be certain not to plant such crops as corn or sorghum following double rates of Treflan or Tolban.

Eradicane (EPTC) has given partial control of rhizome johnsongrass in corn when used at a rate of 7⅓ pints of Eradicane 6.7E per acre as a preplant incorporated treatment. However, this rate of Eradicane increases the risk of corn injury. Sutan+ can be used for controlling both rhizome johnsongrass and seedling johnsongrass.

Dalapon can be used to treat emerged johnsongrass before planting corn or soybeans. Apply 5 to 7 pounds per acre after the grass is 8 to 12 inches tall. Plow about a week later and then delay planting corn or soybeans about 2 weeks. See the label for specific intervals.

Dalapon also can be used to control johnsongrass after wheat that is not double-cropped. A combination of mowing, timely dalapon application, and tillage has provided quite effective control of johnsongrass. However, much of the wheat acreage in the johnsongrass area is double-cropped.

Roundup (glyphosate) can be used to control johnsongrass before planting either corn or soybeans. Apply 2 to 3 quarts in the spring when johnsongrass has reached at least 12 inches and is actively growing. However, one of the best times to apply Roundup is in small grain stubble when the johnsongrass approaches the early head stage. It also may be applied in the fall before johnsongrass turns brown. Three to 7 days should be allowed after application before tillage.

Quackgrass

Quackgrass is a perennial grass primarily found in northern Illinois. Most preemergence herbicides will not control it because it is a perennial.

Atrazine, however, is quite effective when used as a split application in corn. Apply 2½ pounds of atrazine 80W per acre in the fall or spring and plow 1 to 3 weeks later. Another 2½ pounds per acre should be applied as a preplant or preemergence treatment. A postemergence application is possible but is usually less effective. A single treatment with 3¾ to 5 pounds per acre can be applied either in the spring or fall 1 to 3 weeks before plowing, but the split application usually gives better control of annual weeds. If more than 3¾ pounds of atrazine is applied per acre, do not plant crops other than corn or sorghum the following year.

Eradicane (EPTC) can be used to suppress quackgrass in corn where more flexibility in cropping sequence is desired. A rate of 4¾ pints per acre of Eradicane 6.7E can be used on light infestations, while 7⅓ pints per acre is suggested for heavier infestations. There is some risk of corn injury, especially at the higher rate. A tank mix with atrazine should improve control with lower rates of Eradicane.

Dalapon can be applied to quackgrass 4 to 6 inches tall in the spring at a rate of 8 pounds per acre. Plow after 4 days and delay planting corn for 4 to 5 weeks. Up to 15 pounds of dalapon per acre may be used in the fall.

Roundup (glyphosate) can be used for controlling quackgrass before planting either corn or soybeans. Apply 2 to 3 quarts per acre when quackgrass is 6 to 8 inches tall and actively growing (fall or spring). Delay tillage for 3 to 7 days after application.

Canada Thistle

Canada thistle is a perennial weed which, like most perennials, has large food reserves in its root system. Repeated cultivation or mowing can deplete the root reserves and eventually may kill Canada thistle. However, use of herbicides is usually easier, more effective, and more economical. There are several varieties of Canada thistle. They differ not only in appearance but also in their reaction to herbicides.

2,4-D may give fairly good control of some strains. Rates will depend on where the thistle is growing. For example, higher rates can be used in grass pastures or in noncrop areas than in corn. **Banvel** often is a little more effective than 2,4-D and may be used alone or in combination with 2,4-D.

Atrazine and oil applied postemergence has been fairly effective in controlling Canada thistle in corn. Make the application before thistles are 6 inches tall. **Basagran (bentazon)** can be used for control of Canada thistle in soybeans when the thistles are 6 to 8 inches tall. Apply 1 to 1½ quarts per acre in a single application, or, for better control, make two ¾-quart per acre applications 10 to 14 days apart.

Roundup (glyphosate) can be used at 2 to 3 quarts per acre when Canada thistle is 10 inches or more high or approaching early bud stage. Fall treatments must be applied before frost for best results. Allow 3 or more days after application before tillage.

Amitrole or Amitrole-T, quite effectively controls Canada thistle, but can be used only in noncrop areas. **Tordon (picloram)** gives good control of Canada thistle, but soybeans and most other broadleaf plants are extremely sensitive. Use only on noncropland.

Wild Garlic and Wild Onion

Wild garlic and wild onion are perennials that sprout in the fall from underground bulbs and aerial bulblets. Aerial bulblets form in May in both wild garlic and wild onion. These plants mature about the same time as wheat and become dormant in early July. Thus, the greatest problem is in winter wheat where the aerial bulblets are harvested with the grain. Such contaminated wheat is often docked to feed grain prices or even refused at elevators.

2,4-D can be applied to winter wheat in the spring after the wheat tillers but before it reaches the boot stage (wheat head still inside the stem). Earlier application may reduce tiller production, while spraying during boot stage or later may injure the wheat and reduce yields. The proper time to spray winter wheat is usually late March or early April.

Ester formulations of 2,4-D have provided better control than have amine formulations. Rates of ½ to 1 pound of 2,4-D ester or ¾ to 1½ pounds of 2,4-D amine per acre may be used. These rates may reduce wheat yields and probably will kill legume underseedings. Only about a third to a half of the wild garlic or wild onion will be killed, but the remaining plants may be so distorted that the combine header can be set to miss most of the aerial bulblets.

Banvel (dicamba) also is registered, but the legal rate in wheat is too low for effective control of wild garlic. Banvel K is a commercial mixture of dicamba and 2,4-D amine. See the "Herbicides for Small Grains" for more information.

Wild garlic and wild onion are not usually problems in cultivated row crops such as corn and soybeans. Fall or early spring plowing plus spring tillage and cultivation greatly reduces the growth and reproduction of these weeds. Three or four years of such a program greatly reduces the problems of wild garlic or wild onion.

2,4-D used on corn stubble fields or on grass pastures in the late fall or early winter also can help. In grass pastures, 1 to 2 pounds of 2,4-D ester per acre applied in late fall or early spring has sometimes given effective control of wild garlic and wild onion. Banvel can also be used in grass pastures at higher rates than with winter wheat, but be sure to take appropriate precautions (see "Herbicides for Grass Pastures" section).

Additional Information

Not all herbicides and herbicide combinations available are mentioned in this publication. Some are relatively new and are still being tested. Some are not considered to be very well adapted to Illinois or are not used very extensively. For further information on field crop weed control, consult your county extension adviser or write to the Department of Agronomy, N-305 Turner Hall, University of Illinois at Urbana-Champaign, Urbana, Illinois 61801.

Relative Effectiveness of Herbicides on Major Weeds

This chart gives a general comparative rating. Under unfavorable conditions, some herbicides rated good or fair may give erratic or poor results. Under very favorable conditions, control may be better than indicated. Type of soil is also a very important factor to consider when selecting herbicides. Rate of herbicide used also will influence results. G = good, F = fair or variable, and P = poor.

		Grasses							Broadleaf Weeds								
	Crop tolerance	Foxtail	Barnyardgrass	Crabgrass	Fall panicum	Johnsongrass seedlings	Shattercane	Yellow nutsedge	Annual morningglory	Cocklebur	Jimsonweed	Lambsquarters	Pigweed	Ragweed, common	Ragweed, giant	Smartweed	Velvetleaf
SOYBEANS																	
Preplant																	
Treflan, Tolban, Cobex, Basalin, Prowl	F-G	G	G	G	G	G	G	P	F	P	P	G	G	P	P	P-F	P
Sencor, Lexone+ dininitroaniline	F	G	G	G	G	G	G	P	F	F	F-G	G	G	G	F	G	G
Vernam	F	G	G	G	G	G	G	F	F	P	P	F	G	P	P	P	F
Preemergence																	
Amiben	F-G	G	F-G	F-G	F-G	F	F	P	P	P-F	P-F	G	G	G	F	F-G	F
Lasso	G	G	G	G	G	P-F	P-F	F	P	P	P	F	G	P-F	P	P-F	P
Lasso + Lorox, Maloran	F	G	G	G	G	P	P	P-F	P	F	F	G	G	G	F	G	F-G
Lasso + Sencor, Lexone	F	G	G	G	G	P	P	F	P	F	F-G	G	G	G	F	G	G
Lorox, Maloran	F	F	F	F	F	P	P	P	P	F	F	G	G	G	F	G	F-G
Modown	F	F	F	F	F	P	P	P	F	P	G	G	G	F	P	G	F
Sencor, Lexone	F	F	F	F	F	P	P	P-F	P	F	F-G	G	G	G	F	G	G
Postemergence																	
Basagran	F-G	P	P	P	P	P	P	F	P	G	G	F	F	G	F	G	F-G
Dinoseb	F	P	P	P	P	P	P	P	F	F-G	F-G	G	G	F	F	F-G	F
Dyanap	F	P	P	P	P	P	P	P	F	F-G	F-G	G	G	F	F	F-G	F
Tenoran	F	P	P	P	P	P	P	P	F	F	F	F	F	F	F	F	P
2,4-DB	P-F	P	P	P	P	P	P	P	F-G	G	P-F	F	F	F	F	P	P
CORN																	
Preplant																	
Sutan+, Eradicane	F-G	G	G	G	G	F-G	F-G	F-G	P	P	P	P-F	G	P	P	P	F
Sutan+, Eradicane + atrazine	F-G	G	G	G	G	F-G	F-G	F-G	F-G	F-G	G	G	G	G	F	G	F-G
Princep + atrazine	G	F-G	F-G	F	F	P	P-F	P	F-G	F-G	G	G	G	G	G	G	F
Preemergence																	
Atrazine	G	F-G	G	P	P	P	P	F	G	F-G	G	G	G	G	G	G	F-G
Banvel + Lasso	F-G	G	G	G	G	P-F	P-F	G	P-F	F	F-G	G	G	G	F-G	G	F
Bladex	F-G	F-G	F-G	F-G	G	P	P	P	F	F	G	G	F	G	F-G	G	F
Bladex + atrazine	F-G	F-G	G	F	F-G	P	P	P-F	F-G	F-G	G	G	G	G	F-G	G	F-G
Lasso, Dual	F-G	G	G	G	G	P-F	P-F	F	P	P	P	F	G	P-F	P	P-F	P
Lasso, Dual + atrazine	F-G	G	G	G	G	P	P	F	F-G	F	G	G	G	G	F	G	F
Prowl	F-G	F-G	G	G	G	F	F	P	P-F	P	P	G	G	P	P	F	F
Prowl + atrazine, Bladex	F-G	F-G	G	G	G	F	F	P	F-G	F	G	G	G	G	F	G	F-G
Ramrod, Bexton, Propachlor	G	G	F	F-G	F	P	P	P-F	P	P	P	F	G	P	P	P	P
Postemergence																	
Atrazine + oil	F-G	F-G	G	P	P	P	P	F	G	G	G	G	G	G	F	G	F-G
Banvel	G	P	P	P	P	P	P	P	G	G	G	G	G	G	G	G	F
Bladex	F-G	G	G	F	F	P	P	F	F	F-G	G	G	F-G	G	F	G	F
2,4-D	F-G	P	P	P	P	P	P	P	G	G	F	G	G	G	G	P-F	F-G

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1978 HERBICIDES FOR COMMERCIAL FRUIT CROPS IN ILLINOIS

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The suggestions in this publication comply with the regulations of the U.S. Department of Agriculture and the Environmental Protection Agency in effect at the time this publication was assembled. Since such regulations are subject to change, consult the most recent product label for use restrictions. *Do not use any herbicide unless the label states that it may be used on the crop to be treated.*

When mixtures of chemicals are applied, the user will assume the responsibility for freedom of residues if such applications are not labeled by the EPA as a mixture.

This guide is provided for your information. The University of Illinois and its agents assume no responsibility for results from using herbicides, whether or not they are used according to suggestions, recommendations, or directions of the manufacturer or any governmental agency.

CAUTION

Rates are in the amounts of *product* rather than in amounts of *active ingredients* given in previous editions.

All rates are for heavy-textured, mineral soils. Reduce rates proportionately with soil texture to one-half rate for sandy soils. Most of these materials are not effective on peat and muck soils.

CROP	CHEMICAL AND/OR TRADE NAMES AND FORMULATIONS	AMOUNT OF PRODUCT PER TREATED ACRE	REMARKS
APPLES	Sinbar 80W or Princep 80W or Karmex 80W	2 to 4 lb. 2-1/2 to 5 lb. 2 to 4 lb.	These are preemergence herbicides. They may be used in conjunction with a postemergence herbicide. Apply in the spring before weeds emerge. Do not use on sandy soil. Do not use Sinbar on trees established less than 3 years, or Princep or Karmex on trees established less than 1 year. Do not use Karmex on dwarf trees. Half rate of two of these materials is sometimes more effective than a full rate of one material.
	Paraquat CL	1 to 2 qt.	A postemergence herbicide. Use lower rate on young, tender weeds and higher rate on older weeds. Use 8 oz. of nonionic surfactant per 100 gal. of spray to increase effectiveness. Wet foliage! Keep off tree foliage and tender bark. May be used in conjunction with a residual herbicide. Paraquat kills the tops but frequently does not kill the roots. Some growers have successfully used paraquat alone as a strip spray under trees, making two or three applications during the growing season.
	2,4-D amine, oil-soluble amine, and acid forms Formula 40 4EC Dacamine 4EC Weedone 638 3EC and others	see remarks	Use 2 quarts of 4EC amine or oil-soluble amine forms, or 2 quarts of 3EC acid form plus 2 oz. of surfactant per 100 gal. of water. Spot treat in May, June, July, and August to control bindweed, climbing milkweed, and other broad-leaved weeds. Spray before vines climb into trees. Keep spray drift off apple foliage. May be used as a broadcast treatment in late fall to kill dandelions.
	Ammate X 95W	see remarks	For poison ivy, use 60 lb. per 100 gal. of water. Spot treat in May, June, and July, wetting the ivy foliage. Keep off apple foliage.

CROP	CHEMICAL AND/OR TRADE NAMES AND FORMULATIONS	AMOUNT OF PRODUCT PER TREATED ACRE	REMARKS
APPLES (Continued)	Casoron 4G	150 lb.	This material is both a postemergence herbicide and a residual herbicide. Its action is good in cool weather but dissipates after about 2 months of warm weather. Effective against quack grass when applied in late fall. Use granular form. Apply any time from fall to early spring. Can be applied on young trees 30 days after planting.
	Roundup 4EC	1-1/2 to 3 qt.	Limited to use on nonbearing trees only. Roundup is a systemic-type postemergence herbicide to be used in a manner similar to Paraquat. Use sufficient water to wet grass and weed foliage. Keep off apple foliage and green-colored bark tissue. It is more effective than Paraquat against perennials.
PEARS	Same as apples, EXCEPT that Sinbar and Roundup are not registered for pears.		
PEACHES	Princep 80W or Sinbar 80W or Karmex 80W	2-1/2 to 5 lb. 2 to 4 lb. 2 to 4 lb.	See remarks under apples. Do not apply Princep on trees established less than 1 year, or Sinbar or Karmex on trees established less than 3 years.
	Paraquat CL	1 to 2 qt.	See remarks under apples.
	Treflan 4EC	1 qt.	Incorporate into soil before planting tree. Treflan is volatile. Incorporate into soil with a rototiller or by discing twice within 30 minutes after application. Band applications are suggested.
CHERRIES AND PLUMS	Princep 80W	2-1/2 to 5 lb.	See remarks under apples.
	Paraquat CL	1 to 2 qt.	See remarks under apples.
BLACKBERRIES AND RASPBERRIES	Karmex 80W or Princep 80W or Princep 4G	2 to 4 lb. 2-1/2 to 5 lb. 50 to 100 lb.	For plantings at least 1 year old. Apply in spring before weeds emerge and before canes leaf out. Apply to soil surface at base of plants in a band 30 to 42 inches wide along each side of the row. If winter weeds are a problem in established plantings, use half dosage in late fall and again in early spring. Treated area should not be disturbed or have untreated soil piled over it by cultivating equipment.
	Casoron 4G	100 lb.	Use 4-percent granules. Apply any time from late fall to early spring to kill existing grass and weeds and to reduce growth of young weeds into early summer. Can be applied on new plantings 30 days after planting.
	Enide 50W	12 lb.	Apply as a band application on new plantings, except everbearing types. Do not apply within 12 months of harvest.
	Dow General Weed Killer		See remarks under blueberries.

CROP	CHEMICAL AND/OR TRADE NAMES AND FORMULATIONS	AMOUNT OF PRODUCT PER TREATED ACRE	REMARKS
BLUEBERRIES	Karmex 80W or Princep 80W or Princep 4G or Sinbar 80W	2 to 4 lb. 2-1/2 to 5 lb. 50 to 100 lb. 2 to 4 lb.	See remarks under blackberries and raspberries.
	Casoron 4G	100 lb.	See remarks under blackberries and raspberries.
	Dow General Weed Killer		Use 2 to 3 pints in 10 to 20 gallons of No. 2 diesel fuel made up to 100 gallons with water. Wet weed foliage in the fall after harvest or in the spring before bloom. Use directed spray and do not treat young shoots that one does not wish to kill. See label for mixing instructions.
GRAPES	Karmex 80W or Princep 80W	2 to 6 lb. 2-1/2 to 6 lb.	Use in vineyards established at least 3 years. Apply in early spring to soil under trellis in a band 30 inches wide.
	Paraquat CL	1 to 2 qt.	Apply as a postemergent spray when annual grasses and weeds become a problem. Keep spray off foliage. Use the surfactant suggested by the manufacturer.
	Casoron 4G	150 lb.	Use 4-percent granules. Apply from late fall to early spring to kill established weeds and grass. Residual effect to kill germinating weeds and grass will last until warm weather.
STRAWBERRIES (New plantings)	Dacthal 75W	12 lb.	Preemergence action. May be applied immediately after transplanting or during the growing season to weed-free soil. To be most effective, Dacthal should be incorporated into the top 1/2 inch of soil with water. Will not control ragweed, smartweed, or morning glory. Effective weed control generally lasts 4 to 8 weeks. May be repeated. Cultivation destroys effectiveness.
	Enide 50W	12 lb.	Preemergence action. During the first growing season may be applied anytime after the plants become established and the soil is free of weeds. Incorporate in the soil with rainfall or irrigation. May be applied in late fall or early spring to give control through harvest. Do not apply within 60 days before harvest. No more than two applications per year. Cultivation destroys effectiveness.
	Norex 50W or Tenoran 50W	8 lb. 8 lb.	Postemergence action against young weeds plus some preemergence action. Delay application on new plantings until strawberry plants become established. Not effective on grasses, but will kill many broad-leaved weeds that are less than 1 inch high. Irrigate as soon as possible after application if soil is dry. Do not apply when temperature is above 90° F., because injury to foliage may occur. Cultivation will destroy effectiveness. No more than two applications per year. Follow special mixing instructions. Do not apply within 60 days before harvest.

CROP	CHEMICAL AND/OR TRADE NAMES AND FORMULATIONS	AMOUNT OF PRODUCT PER TREATED ACRE	REMARKS
STRAWBERRIES (Established plantings)	Dacthal 75W	12 lb.	Preemergence action. See remarks for new plantings. Do not apply when blossoms or fruit are present.
	Enide 50W	12 lb.	Preemergence action. Apply after renovation or in late fall or early spring. For best results, irrigate immediately or apply to moist soil. Apply before weeds germinate. Effective against fall- and spring-germinating grasses and some broad-leaved weeds. A late August application controls winter annuals. A late fall application just before mulching should control spring-germinating grasses and weeds through harvest. Do not apply within 60 days before harvest. No more than two applications per year.
	2,4-D amine Formula 40	1 to 1-1/2 qt.	Postemergence action. To control many broad-leaved weeds in established plantings apply in 25 to 50 gallons of water per acre in late fall or early spring when strawberries are dormant. 2,4-D may also be applied at renovation time.
	Norex 50W or Tenoran 50W	8 lb. 8 lb.	May be applied at renovation time. It will kill some existing weeds and also give some preemergence protection. It may also be applied in early spring to kill existing chickweed. Do not apply within 60 days before harvest. Do not make more than two applications per year.

Cautions

If you are applying herbicides for the first time or are trying a new herbicide, learn on a small area.

Avoid spray drifts. Use low pressure (30 to 60 pounds per square inch) with nozzles close to the ground. Spray when wind velocity is low.

Calibrate equipment to apply the correct amount of material per acre. Excessive amounts may cause damage to fruit plants. Lesser amounts may not give control. Uniform application is essential.

Clean sprayers after applying herbicides. Use detergent and water (2 cups in 25 gallons) or ammonia and water (1 quart in 25 gallons) to clean out wettable-powder sprays. Emulsifiable liquids should first be washed out with kerosene, then with detergent and water or ammonia and water. Do not allow drain solutions to run into streams or other water sources.

For herbicide suggestions in home fruit plantings, see Circular 1144, "Controlling Weeds in Home Fruit Plantings."

Calibration of Sprayers

Pressure, the size and number of nozzles, and tractor speed all affect the quantity of liquid applied per treated acre. These should be adjusted according to manufacturer's recommendations.

After adjustment, make a trial run with water only. Fill the tank with water, spray a measured area, and measure the amount of water required to refill the tank. Convert the results into gallons applied per acre. (The amount of water used divided by the portion of an acre covered will give the gallons per acre being applied.) A range of 50 to 100 gallons per sprayed acre is suggested for tree fruits, a range of 30 to 60 gallons per acre for small fruits. Add herbicide according to the amount of product suggested per treated acre and the gallons applied per acre.

Example: With a pressure of 30 p.s.i. and a tractor speed of 3 m.p.h., 30 gallons were applied on a treated 1/2 acre. The sprayer, then, is applying 60 gallons per acre. The amount of product per 100 gallons then would be as follows:

$$\frac{\text{lb. of product per acre x 100 gal.}}{\text{gallons applied per acre}} = \frac{4 \times 100}{60} = 6.7 \text{ lb. of product per 100 gallons.}$$

Herbicide Guide 1978
FOR COMMERCIAL VEGETABLE GROWERS

WEED GROWTH reduces the income of vegetable growers in the United States by millions of dollars annually as a result of lower yields, poorer quality, and added labor in harvesting and processing.

This guide should be used together with the grower's knowledge of soil types and the crop and weed history of the area to be treated. Whether to use herbicides or other means of weed control depends in part on the severity of past weed infestations. In many instances mechanical control is sufficient, or it may be needed in addition to herbicide use. Several herbicides may be suggested for some crops. These herbicides have shown good control with no injury to the vegetables under test conditions. Not all herbicides cleared for use on a species are necessarily listed. Where the choice of more than one herbicide is suggested, the decision rests with the grower and is based on his knowledge of past weed infestations, crop rotations, and material costs. Where one herbicide will not control the weeds present, a combination of herbicides may be suggested. When using an herbicide for the first time, use a small-scale trial.

These suggestions for chemical weed control in vegetables are based on research at the Illinois Agricultural Experiment Station, the U.S. Department of Agriculture, and other research institutions. The University of Illinois and its agents assume no responsibility for results from the use of these herbicides, whether or not they were used in accordance with suggestions, recommendations, or directions of the manufacturer or any governmental agency.

Reading the label of the herbicide container is the most profitable time you spend in weed control. Use of the material and methods of application and use depend on registration of the herbicide by federal and state Environmental Protection Agencies (EPA). Do not use any herbicide *unless the label states that it is cleared for the use on the crop to be treated.*

Where mixtures of chemicals are applied, the *user* will assume the responsibility for freedom from residues if such applications are not labeled by the EPA as a mixture.

Suggestions sometimes change during the growing season, based on EPA clearances that were made after this circular was issued. This publication is printed only once each year, and is therefore subject to change without notification.

Watch for notice of changes in the EPA registration of herbicides (as released by the EPA) in the *Illinois Vegetable Farmer's Letter.* A subscription form for this newsletter is available from 116 Mumford Hall, University of Illinois, Urbana 61801.

NOTE: In the suggestions table on the following pages, the trade names of the herbicides are usually used. The list below shows trade names and their corresponding common names.

Common name	Trade name
alachlor	Lasso
atrazine	AAtrex and others
benefin	Balan
bensulide	Prefar
bentazon	Basagran
butylate	Sutan+
CDAA	Randox
chloramben	Amiben, Vegiben 2E
chlorbromuron	Maloran
chlorpropham	Furloe
cyanazine	Bladex
cycloate	Ro-Neet
dalapon	Basfapon, Dowpon
DCPA	Dacthal
dinitramine	Cobex
dinoseb	Premerge-3, Sinox
diphenamid	Dymid, Enide
diuron	Karmex
EPTC	Eptam, Eradicane
glyphosate	Roundup
linuron	Lorox
MCPA	(numerous ones)
MCPB	(numerous ones)
metribuzin	Lexone, Sencor
naptalam	Alanap
nitrofen	TOK
profluralin	Tolban
propachlor	Bexton, Ramrod
pyrazon	Pyramin
simazine	Princep
trifluralin	Treflan
Petroleum solvent	Stoddard Solvent
2,4-D (amine)	(numerous ones)

UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN COLLEGE OF AGRICULTURE COOPERATIVE EXTENSION SERVICE
Prepared by H. J. Hopen, Department of Horticulture (revised annually) CIRCULAR 907 (October, 1977)

USE THESE SUGGESTIONS IN 1978 ONLY

Crop	*Treatment*	*Active ingredient per acre actually covered*[1]	*Weeds controlled*	*Best time of application (based on crop stage)*	*Remarks, cautions, limitations*
Asparagus (seedlings)	Amiben	3 lb.	Annuals	Immediately after seeding	Irrigation or rainfall after treatment will give maximum control.
Asparagus (established plantings)	dalapon	5-10 lb.	Perennial grass	End of harvest season following disking	Apply when grass weeds are 3 to 4 inches tall. Direct spray under fern growth. Use surfactant as directed on label.
	Karmex	1-4 lb.	Annuals	In spring before spears emerge or immediately following harvest, or both	Apply after disking. Do not exceed 6 pounds per growing season. Use lighter rate on sandy soil.
	Princep	3-4 lb.	Annuals	In spring and after harvest	Apply after disking. Do not treat during last year in asparagus because of residue. With Karmex and Princep — usually weed infestation will be reduced and spring application may be sufficient after the first year.
Beans, lima and dry	Amiben	2-3 lb.	Broad spectrum of annual weeds	Immediately after seeding	Field may be rotary-hoed without destroying herbicide action.
	Treflan	0.5-0.75 lb.	Annuals[2] (primarily grasses)	Preplant soil application, incorporate with soil immediately	Plant crop immediately, or within 3 weeks after application. Can be used up to 1 pound on dry beans.
Beans, snap	Eptam	3 lb.	Annual grasses and nutgrass[3]	Preplant soil application, incorporate with soil immediately	
	Treflan	0.5-0.75 lb.	Annuals[2] (primarily grasses)	Preplant soil application, incorporate with soil immediately	Plant crop immediately or within 3 weeks after application.
	Dacthal	6-10 lb.	Annuals[4] (primarily grasses)	Immediately after seeding	Do not feed treated plant parts to livestock.
	Vegiben 2E (2E *only*)	1.5-3 lb.	Broad spectrum of annual weeds	Immediately after seeding	This ester form of chloramben may leach less readily in sandy soils. Use on other than sandy soils.
Beans, dry	Cobex	0.3-0.6 lb.	Annuals	Preplant soil incorporation	
Beans, dry, lima, and snap	Tolban	0.5-1 lb.	Primarily annual grasses	Preplant soil incorporation	
	Premerge-3	6-7.5 lb.	Annuals	Can be used between planting and crop emergence	Do not use on light, sandy soil. Some stand reduction may result from use. See label for precautions.
Beets, garden	Pyramin	4 lb.	Annuals (primarily broadleaved)	Preemergence or after beets emerge and before weeds have two true leaves	Rainfall or irrigation needed to activate. Where grasses are a severe problem, use 4 pounds of Pyramin plus 4 pounds of Ro-Neet.
	Ro-Neet	4 lb.	Annual grasses	Preplant soil application, incorporate with soil immediately	Use a combination treatment with Pyramin to broaden control spectrum.
Broccoli Brussels sprouts Cabbage Cauliflower	**Preemergence — direct-seeded**				
	Treflan	0.5-0.75 lb.	Annuals[2] (primarily grasses)	Preplant soil application, incorporate with soil immediately	Stunting or growth reduction may occur at recommended rates under growth stress conditions.
	Dacthal	6-10 lb.	Annuals[4] (primarily grasses)	Immediately after seeding. Can also be incorporated preplant	Can also be used preemergence on transplants.
	Preemergence — transplanted				
	Treflan	0.5-1 lb.	Annuals[2] (primarily grasses)	Preplant soil application, incorporate with soil immediately	Transplant after application to 3 weeks later.
	Postemergence — direct-seeded or transplanted				
	TOK[5]	3-6 lb.	Broadleaved weeds[6]	One to two weeks after crop emergence or transplanting, while weeds are in seedling stage	Use wettable-powder formulation to reduce injury potential. Use in combination with preplant or preemergence material for annual grass control.
Carrots	**Preemergence**				
	Treflan	0.5-1 lb.	Annuals[2] (primarily grasses)	Preplant soil application, incorporate with soil immediately	Seed after application to 3 weeks later.
	Postemergence				
	Lorox	0.75-1.5 lb.	Annuals	Postemergence on carrots only after the crop is 3 inches tall; grasses, less than 2 inches; broadleaves, less than 6 inches	Do not feed treated foliage to livestock or replant treated area for 4 months. More than one application may be made, but do not exceed a total of 2 pounds per acre. Do not use over 40 PSI. Use no surfactants when temperatures exceed 80°F., or crop injury may result.
	TOK	3-6 lb.	Broadleaved weeds[6]	While weeds are in the seedling stage	Can also be used on celery and parsley. Use in combination with preplant or preemergence material for annual grass control.
	Stoddard Solvent	60-80 gal.	Annuals	After two true leaves have appeared (do not apply to carrots or parsnips after they are ¼ inch in diameter, since an oily taste may result)	Most effective when sprayed on cloudy days or during high humidity, and when weeds are not more than 2 inches high. May not control ragweed. Do not apply within 40 days of harvest. Can also be used on celery, dill, parsnips, and parsley.

Crop	Treatment	Active ingredient per acre actually covered[1]	Weeds controlled	Best time of application (based on crop stage)	Remarks, cautions, limitations
	Preemergence				
Corn, pop	atrazine	2-3 lb.	(See sweet corn)	(See sweet corn)	See sweet corn, *except the section on combinations.*
	Princep	2-3 lb.	Annuals	Preemergence	Plant only crops so specified on the label the following year. Do not graze treated areas.
	Postemergence				
	2,4-D	0.5 lb.	Broadleaved weeds	Postemergence	Apply when corn is 3 to 10 inches tall.
	Roundup	2-3 lb.	(See remarks)	(See remarks)	Use for quackgrass or Johnsongrass control. Apply to quackgrass when 6 to 8 inches tall in fall or spring. Apply to Johnsongrass when at least 12 inches tall and actively growing. Do not till until 3 to 7 days after application.
	Preemergence				
Corn, sweet	atrazine	2-3 lb.	Annuals, annual and perennial grasses[7]	Preemergence, apply no later than 3 weeks after seeding Shallow cultivation may improve weed control during dry weather	Grow corn a second year without atrazine treatment. This chemical has a high soil residue. Do not plant other vegetable crops on a sprayed area until a second year of corn has been grown. Use atrazine where quackgrass is a problem. Residue hazard decreased when banded or in combination with Lasso, propachlor, or Sutan.
	Bladex	(See remarks)	Annuals	Preemergence only	Some sweet corn varieties are sensitive to the application rate. Has been shown to have less soil residual than atrazine. See label for rates and precautions. Do not use postemergence, or on sandy or loamy-sandy soils. Can be combined with other herbicides to reduce the rate being used.
	Lasso	2-2.5 lb.	Annuals	Preemergence	Preplant incorporation may aid control of nutgrass. Do not apply in nitrogen solutions.
	propachlor	4-5 lb.	Annuals	Preemergence	Do *not* use on sandy soils. Is an excellent herbicide on soils with a high organic-matter content.
	Sutan +	3-4 lb.	Primarily annual grasses	Preplant soil application Incorporate with soil	Use on sandy soil and where nutgrass is a problem.
	Eradicane	4 lb.	Difficult to control weeds such as wild cane, nutsedge, quackgrass, and seedling Johnsongrass	Preplant soil application, incorporate with soil	Use to control weeds that are difficult to control with other herbicides, such as wild cane, nutsedge, quackgrass, and seedling Johnsongrass.
	Preemergence combinations				
	atrazine plus Lasso	1.5 lb. +2 lb.	Annuals and perennial grasses	Preemergence or preplant incorporated	See label for slightly higher rate of Lasso for preplant incorporation.
	atrazine plus propachlor	1.5 lb. +3 lb.	Annuals and perennial grasses	Preemergence	Use to reduce atrazine residue.
	atrazine plus Sutan +	1 lb. +3-4 lb.	Annuals and perennial grasses	Preplant soil incorporation Incorporate with soil immediately	Use where nutgrass is a problem and to reduce atrazine residue.
	Postemergence				
	2,4-D (amine)	0.5 lb.	Broadleaved weeds	Postemergence	Preferably, apply before corn is 6 inches tall. If corn is over 12 inches, reduce the rate to ¼ pound.
	atrazine	2 lb.	Annuals, annual and perennial grasses[7]	Directed spray 3 weeks after emergence	Can be combined with crop oils for postemergence application as an emergency measure. This may increase residue the following year. Preemergence use preferred. Do not graze or feed treated foliage for 21 days after treatment.
	Basagran	0.75-1 lb.	Broadleaved annual weeds, Canada thistle, and nutsedge. Will not control grass weeds	Early postemergence when the weeds are small and actively growing. Delay will result in less control	TRIAL USE IN 1978. For Canada thistle and nutsedge, split applications are preferred. Make first one when the plants are 6 to 8 inches tall; for nutsedge, 7 to 10 days later; for Canada thistle, 10 to 14 days later.
	Perennial grass control, applications outside the growing season				
	Roundup	2-3 lb.	(See remarks)	(See remarks)	Use for quackgrass or Johnsongrass control. Apply to quackgrass when 6 to 8 inches tall in fall or spring. Apply to Johnsongrass when at least 12 inches tall and actively growing. Do not till until 3 to 7 days after application. Does not provide residual weed control. Do not mix, store, or apply Roundup spray solutions in galvanized steel or unlined steel containers (except stainless steel) or spray tanks.

[1] Based on active ingredients (actual amount of active herbicide in material or acid equivalent). Use lower rate on sandy soil and higher rate on clay and loam soils. When ısing a band application over the row, adjust amount of material applied to the part of an acre treated. See Illinois Circular 1047. [2] May not control ragweed and panicum. May not control smartweed. [4] May not control ragweed, smartweed, and velvetleaf. [5] Use of 50% wettable powder is suggested for cabbage and horseradish. [6] May not control agweed or chickweed. Grass control is sometimes marginal. [7] May not control crabgrass. [8] Do *not* use Alanap Plus, Solo, Whistle, or Amoco Soybean herbicide. These materials ll contain Alanap plus another ingredient that may cause injury. [9] May not control smartweed and velvetleaf.

Crop	Treatment	*Active ingredient per acre actually covered*[1]	*Weeds controlled*	*Best time of application (based on crop stage)*	*Remarks, cautions, limitations*
Cucumbers Muskmelons Watermelons	Alanap[8]	3-5 lb.	Annuals[3]	Immediately after seeding or transplanting	Do not use on cold soil. Rainfall or irrigation after treatment gives maximum control.
		3-3.5 lb.		After transplanting or vining	Use granular form. Keep away from foliage. Apply to soil after the weeds have been removed.
	Prefar	4-6 lb.	Annuals (primarily grasses)	Preplant soil application, incorporate with soil immediately	Is primarily a grasskiller. Consult label for sensitive crops within 18 months after application. Prefar can be used in rotation with tomatoes, broccoli, cauliflower, lettuce, carrots, onions, and summer squash within 18 months of application.
	Prefar plus Alanap[8]	4 lb. +2-3 lb.	Grasses and broadleaved weeds	Preplant soil incorporation for Prefar; Alanap, as an immediate postseeding application	Has value for broad-spectrum weed control. Consult label for sensitive crops within 18 months after Prefar application. Has EPA approval as a tank mixture.
	Vegiben 2E (2E form *only*)	1.5-3 lb.	Broad spectrum of annual weeds	Immediately after seeding	This ester form of chloramben may leach less readily in sandy soils. Above 1.5 to 2 pounds per acre, injury chances increase under moist soil conditions. Some muskmelon cultivars may be susceptible to Vegiben injury.
	As an alternative to herbicides where earliness is desired, black polyethylene mulch will control annual weeds, conserve moisture, and increase early spring soil temperatures.				
Eggplant	Dacthal	6-10 lb.	Annuals[4] (primarily grasses)	After plants are established, 4-6 weeks after transplanting	Cultivate and weed prior to application. Can be applied to plants as part of a uniform soil application.
Greens	Dacthal	6-10 lb.	Annuals[4] (primarily grasses)	Immediately after seeding	For use on collards, kale, mustard greens, and turnips.
	Treflan	0.5-0.75 lb.	Annuals[2] (primarily grasses)	Preplant soil application. Incorporate with soil immediately	For use on collards, kale, mustard greens, and turnip greens.
	Furloe	1-2 lb.	Primarily broadleaved annuals	Preemergence	For spinach only. Use lower rates in cool, wet weather.
Horseradish	Dacthal	6-10 lb.	Annuals[4] (primarily grasses)	Immediately after transplanting	Use for annual grass control and combine with TOK as an early postemergence treatment for broadleaved weeds.
	TOK[5]	3-6 lb.	Broadleaved weeds[6]	Before weeds are 1 inch tall	Will not consistently control weeds over 1 inch tall. Some emerging annual grass may be controlled by this treatment. Lower rate will control seedling purslane.
Lettuce	Balan	1.5 lb.	Annuals	Preplant soil incorporation Incorporate with soil immediately	Is primarily a grasskiller. Seed after application to 3 weeks later. Do not plant wheat, barley, rye, grass, onions, oats, beets, or spinach for 12 months after application.
	Preemergence				
Onions	Dacthal	6-10 lb.	Annuals[4] (primarily grasses)	Immediately after seeding or transplanting	May not kill smartweed or common ragweed. Can be used on seeds, sets, or seedlings. Use only on mineral soils. Use lower rates on sandy soils. A double application of Dacthal can be used at seeding, layby, or both. In most situations, the weed spectrum on mineral soils will respond well to a combination of Dacthal preemergence and TOK postemergence.
	Randox	4-6 lb.	Annuals[9] (primarily grasses)	Just before onions emerge	Use on muck soils. Heavy rainfall may reduce stand. Very effective on purslane and pigweed.
	Postemergence				
	TOK	3-4 lb.	Broadleaved weeds	When weeds are in seedling stage and not over 1 inch tall	Use a single application of E.C. or W.P. per growing season. Do not apply E.C. until onions are in the two- to three-leaf stage. *Preemergence* use of TOK with heavy rainfall may reduce stand. Use in combination with preplant or preemergence material for annual grass control.
	Furloe	3-6 lb.	Broadleaved weeds (especially smartweed)	On seeded onions: loop stage or after three- to four-leaf stage	In the later sprays, direct at base of onion plant. If more than one application is applied do not exceed 6 pounds per acre for the season. *Use lower rates in cool, wet weather.* Use no later than 30 days before harvest.
Peas	propachlor	4-4.9 lb.	Annuals	Preemergence	Do *not* use on sandy soil.
	Treflan	0.5-0.75 lb.	Annuals[2]	Preplant soil incorporation Incorporate with soil immediately	Seed after application to 3 weeks later. Some reduction of growth and stand reduction possible under stress.
	Cobex	0.3-0.5 lb.	Annuals	Preplant soil incorporation	
	MCPB	1 lb.	Broadleaved weeds and Canada thistle	When peas are 3-7 inches tall and no later than four nodes prior to pea blossom	May delay maturity 1 to 4 days. Use at least 20 gallons of water per acre. Do not feed vines to livestock.
	MCPA	0.25-0.5 lb.			MCPA is more effective on mustard. MCPB is less injurious to peas.
	Premerge-3	0.3-9 lb.	Annuals (primarily broadleaved weeds)	Preemergence or postemergence	Preemergence use 6 to 9 pounds; postemergence, use 0.3 pound to 1.1 pounds. Apply prior to bloom when peas are 2 to 8 inches tall. See label for further precautions.

Crop	Treatment	Active ingredient per acre actually covered[1]	Weeds controlled	Best time of application (based on crop stage)	Remarks, cautions, limitations
Potatoes, Irish	Eptam	3-6 lb.	Annual grasses and nutgrass[3]	Drag-off treatment at emergence or preplant soil application Incorporate with soil immediately	Use lower rate on sandy soil.
	Treflan	0.5-1 lb.	Annuals[2] (primarily grasses)	Drag-off treatment at emergence	Use a light incorporation.
	Lorox	0.75-2 lb.	Annuals	Apply prior to potato emergence	Plant tubers at least 2 inches deep. Do not replant treated area to other crops for 4 months after treatment. May injure crop on light, sandy soil. Do not apply over exposed tubers.
	chlorbromuron	2-3 lb.	Annuals	At very start of potato emergence	May injure crop on light, sandy soil. Do not harvest immature potatoes. Do not plant crops other than field corn, potatoes, or soybeans for 6 months after applying.
	dalapon	7 lb.	Quackgrass	Before plowing in spring; wait 4 days before plowing and planting	Not for fields intended for red-skinned varieties or White Rose. Do not plant potatoes for 4 weeks. Use surfactant as directed on label.
	metribuzin	0.25-0.5 lb.	Annuals (primarily broadleaved)	Postemergence, following a preemergence grass herbicide	Can be used preemergence also. Do not exceed 1 pound per acre in a season. Do not apply within 60 days of harvest. Do not use on red-skinned or early maturing white varieties. Do not apply in cool, wet weather.
	Lasso	2.5-3 lb.	Annuals	Apply at drag-off	Do not use on sandy soils. Can be used alone or in combination with Lorox or dinoseb.
Potatoes, sweet	Dacthal	6-10 lb.	Annuals[4] (primarily grasses)	Immediately after planting	May not control smartweed or common ragweed. Preferred on sandy soil.
	Amiben	3 lb.	Annuals	Immediately after planting	Preferred on loam soils.
Spinach	Furloe	1-2 lb.	Annuals	Immediately after seeding	Use 1 pound if the temperature is below 60°F.
Squash Pumpkins	Amiben	3-4 lb.	Annuals	As soon after seeding as possible	Use on loam soils. In Illinois, Amiben can be applied broadcast or banded over the row in pumpkins.
Squash	Prefar	4-6 lb.	Annuals (primarily grasses)	Preplant soil application Incorporate with soil immediately	Is primarily a grasskiller. Consult label for sensitive crops within 18 months after application. Prefar can be used in rotation only with tomatoes, broccoli, cauliflower, lettuce, carrots, onions, and summer squash within 18 months of application. Use in combination with Alanap as suggested for cucumbers.
Tomatoes, direct-seeded	Dymid, Enide	4-6 lb.	Annuals	Preemergence	Do not plant other food crops on treated areas for 6 months. If used under dry soil conditions, a shallow (1 inch) incorporation as a preplant treatment may improve weed control. Can also be used on transplanted tomatoes and peppers.
Tomatoes and Peppers, transplanted	Amiben	3-4 lb.	Annuals	Wait 3 days after transplanting to apply	Use granular formulation only. Apply to dry foliage in order to avoid leaf burn. Do not use on sandy soils.
	Treflan	0.5-1 lb.	Annuals[2] (primarily grasses)	Preplant soil application Incorporate with soil immediately	Some reduction of growth may be possible under growth stress conditions, or if rates are higher than suggested for the soil type.

Storage of Pesticides and Containers

Keep pesticides and containers in a separate building, room, or enclosure used only for this purpose. Such buildings or rooms hould be dry, ventilated, and locked. Fence outside storage areas to protect children and animals and to discourage pilferage. CAU-ION: Do not store weedkillers, herbicides, or defoliants in the same room with insecticides. Chlorate salts can create a fire or xplosion hazard. Remove only the pesticides needed for one day's operation and return empty containers — and any unused pesti-ide — to the storage area each day.

Disposing of Pesticides and Containers

Surplus Pesticides. To dispose of surplus pesticide mixtures, try to find other areas with the same pest problem and use up ny extra tank mix or rinse water on these areas. Do not drain surplus pesticides in any location where they can contaminate vells, streams, rivers, lakes, or ponds.

Operators of landfills meeting environmental safety standards can obtain supplemental permits to handle toxic waste naterials, including pesticides. To dispose of large quantities of surplus pesticides, contact the Illinois EPA Division of Land Pollution Control to locate the nearest landfill with a supplemental permit for toxic waste or to obtain specific instructions bout disposal.

Pesticide Containers. All empty pesticide containers, regardless of their type, should be rinsed three times before disposal. Rinse water should be dumped in the tank. Triple-rinsed containers should be punctured or broken to facilitate drainage nd to prevent reuse for any purpose. They should then be hauled to a sanitary landfill for disposal. Small quantities of con-ainers may be buried singly in open fields, with due regard for the protection of surface and subsurface water.

Illinois regulations permit the burning of combustible containers provided that they are burned on the premises where hey were used, that they are burned more than 1,000 feet from residential areas, that the burning will not cause undue visi-ility or environmental hazards, and that no reasonable alternate disposal method is available.

Do not breathe smoke from burning pesticide containers, and do not burn containers that have weedkillers such as 2,4-D or similar herbicides. When these change to a gas, the vapors may damage nearby crops and shrubbery. Pesticides containing chlorates may explode when heated and, therefore, should not be burned.

OTHER PUBLICATIONS ON WEED CONTROL

Obtain the following publications on weed control from the office of your county Extension adviser (agriculture) or by writing to the Office of Agricultural Publications, 123 Mumford Hall, Urbana, Illinois 61801.

Prevent 2,4-D Injury to Crops and Ornamental Plants — Circular 808

Legal Aspects of Crop Spraying — Circular 990

Calibrating and Adjusting Granular Row Applicators — Circular 1008

Calibrating and Maintaining Spray Equipment — Circular 1038

Band Spraying Preemergence Herbicides — Circular 1047

Controlling Weeds in the Home Garden — Circular 1051

Turfgrass Pest Control — Circular 1076

Herbicides for Commercial Fruit Crops in Illinois — H-659

1978 Field Crops Weed Control Guide

CONTROLLING WEEDS in HOME FRUIT PLANTINGS

Grassy and broadleafed weeds in home fruit plantings reduce yields, are unsightly, and may harbor injurious insects and mice. This publication is designed to aid home fruit growers in controlling these pest plants.

WEED CONTROL METHODS

Weed control methods available for the home fruit grower include using organic mulches, mowing, cultivating, hand hoeing, pulling weeds, and using herbicides. Usually a combination of these methods is the most practical approach.

Mulching

Both tree fruits and small fruits, except strawberries, thrive under mulch culture (for strawberries, a modified mulch culture is suggested for winter protection). Organic mulches such as straw, hay, grass clippings, sawdust, hardwood bark, and chopped corn cobs are preferred. These mulches smother weeds, conserve moisture, reduce soil temperature fluctuations, and add organic matter to the soil. Keep the mulches about 6 inches deep. Because mulches may harbor mice, which damage fruit plants, use traps or bait or a good cat to keep mice under control.

Cultivating, Hoeing, and Pulling Weeds

Cultivation is usually the most practical method of controlling the weeds and grass that grow in the aisles between rows of brambles, grapes, and strawberries. Hand hoeing and weed pulling will occasionally be needed to remove weeds that escape other control methods.

Mowing

The area between fruit trees usually is kept in bluegrass sod. Mowing is the most practical means of keeping weeds under control in this area. Mowing is also useful in the aisles between rows of grapes, blueberries, and brambles.

Herbicides

Herbicides (chemical weed killers) can be used safely in home fruit plantings if the directions are followed carefully. Residual-type herbicides must be applied in the correct amount per area. Exceeding the recommended rate may damage fruit plants; using less than the recommended rate may not control weeds. Do not use residual-type herbicides on sandy soils.

ECONOMICS OF CHEMICAL WEED CONTROL

Chemical weed control probably is not practical for home gardeners with small plantings of fruit plants. Mulching, cultivation, hoeing, and weed pulling are the most practical weed control methods for small plantings.

Gardeners with larger plantings may find chemical weed control economically feasible. Farm families may currently be using some of the suggested herbicides in their farming operations and thus may already have them on hand.

Most of the herbicides suggested are packaged in 4- or 5-pound bags for wettable powders or in gallon containers for liquids. Purchasing that much herbicide represents a considerable investment. Herbicides will retain their effectiveness over several years, however, if they are stored in a dry area.

SUGGESTED HERBICIDES

The herbicides suggested in this circular are wettable powders (WP), granules (G), or liquids (L). Wettable powders and liquids are mixed with water for application. Granular herbicides are applied in the dry form.

Diuron (Karmex), simazine (Princep), DCPA (Dacthal), and diphenamide (Enide)[1] are residual-type herbicides. Like most residual types, they work primarily against germinating weeds but have little or no effect on existing weeds. Any existing weeds should be removed by cultivation or killed with a contact-type herbicide before applying residual herbicides.

Dichlobenil (Casoron) is a residual herbicide that also has excellent eradicative action (kills existing weeds). It is volatile in hot weather and loses its effectiveness by early summer. When applied in late fall, winter, or early spring, Casoron kills existing weeds and acts as a residual herbicide against germinating weeds. It is especially useful in cleaning out weedy patches of raspberries, blackberries, and blueberries.

Residual herbicides do not become active until they are incorporated into the top layer of the soil. A half-inch of rain or irrigation water is sufficient for incorporation. These herbicides will be effective against new weed seedlings for varying lengths of time. Cultivation destroys their effectiveness. None of the residual herbicides is effective against all species of weeds; some hand hoeing and weed pulling will be necessary. Do not use residual-type herbicides on sandy soils.

Paraquat (Paraquat), a nonselective contact-type herbicide, burns any foliage it contacts. It is useful under fruit trees and grapevines where the weeds can be sprayed without getting any spray material on the leaves of the fruit plants. Paraquat has been listed as a restricted pesticide by the Environmental Protection Agency; therefore, sale and use are limited to certified private applicators.

Amine 2,4-D is a growth-regulator-type herbicide that is effective against many species of broadleafed weeds. It can be used under apple and pear trees as needed; at certain times of the year, it can be used on strawberries.

Where to Buy

Farm supply stores frequently carry Paraquat, Princep, Dacthal, and amine-type 2,4-D. In areas where vegetables and fruits are produced commercially, these stores may also carry Karmex, Enide, and Casoron.

Garden centers and seed stores frequently carry Dacthal and amine-type 2,4-D. Some of them may also have Karmex, Princep, Enide, and Casoron.

WEED CONTROL PROGRAMS

Fruit Trees

Young fruit trees need to be protected from competition by weeds for five years after planting. Organic mulches, cultivation, or herbicides may be used.

If the mulch program is to be used, apply the mulch soon after planting. Cover all the soil within 2 feet of the trunk. As the trees grow, the mulch may be extended to cover the area under the branches. If the mulch is maintained, cultivation or herbicides will not be needed.

If newly planted trees are not mulched, the soil within 2 feet of the trunk should be cultivated shallowly during the first growing season. The cultivated area may be larger if desired.

After the first growing season, cultivation or mulching may be continued or herbicides may be applied. The residual herbicides Princep or Karmex should be applied in the spring to bare soil or to areas where the existing weeds have been killed with Paraquat. The herbicide may be applied to a circular area extending 3 feet from the trunk, or to an area 4 feet square with the tree in the center, or to a 3- to 4-foot-wide strip down the tree row.

Starting with the sixth growing season, mulching or herbicide application may be continued, or closely mowed grass can be allowed to grow under the trees. A 12-inch-wide gravel or sand collar around each tree prevents the growth of weeds and grass next to the trunk and eliminates the possibility of mower injury to the trunk.

Apples and Pears

Princep 4G........	3½ ounces treats 100 square feet 2 pounds, 4 ounces treats 1,000 square feet
Princep 80 WP....	1 teaspoon treats 34 square feet 1 tablespoon treats 102 square feet
Karmex 80 WP....	1 teaspoon treats 48 square feet 1 tablespoon treats 144 square feet
Paraquat..........	See section on Paraquat (page 10)
Amine 2,4-D	See section on 2,4-D (page 11)
Casoron 4G........	5½ ounces treats 100 square feet 3 pounds, 7 ounces treats 1,000 square feet

Peaches

Princep 4G........	Same as apples
Princep 80 WP....	Same as apples
Karmex 80 WP....	Same as apples
Paraquat..........	See section on Paraquat (page 10)
Casoron 4G........	Same as apples

Cherries and Plums

Princep 4G........	Same as apples
Princep 80 WP....	Same as apples
Paraquat..........	See section on Paraquat (page 10)
Casoron 4G........	Same as apples

Suggestions and restrictions. Princep: Apply in spring or early summer to bare ground, or apply soon after Paraquat has been used to burn existing foliage. Do not apply on trees established less than one year. Make only one application per year.

Karmex: Apply in spring or early summer to bare ground, or apply soon after Paraquat has been used to burn existing foliage. Do not apply on apples and pears established less than one year or on peaches established less than three years. Make only one application per year.

Casoron: Apply in late fall, winter, or early spring. Make only one application per year.

Blackberries, Raspberries, and Blueberries

During the first growing season after planting, these plants should be mulched or cultivated. Mulching is preferred because it reduces the need for watering. However, the mulch must not be so deep that it prevents the new shoots from coming through. This is especially important for blackberries and red raspberries, which send up new shoots several inches from the main plant. During the second growing season and subsequent seasons, mulching or cultivation may be continued or herbicides may be used.

Casoron is especially useful to clean out existing weeds. It is also effective against germinating weeds until hot weather.

Karmex or Princep should give fairly good weed control throughout the growing season. In southern Illinois, foxtail and fall panicum may grow through the herbicide band in late summer.

Princep 4G........	3½ ounces treats 100 square feet 2 pounds, 4 ounces treats 1,000 square feet
Princep 80 WP....	1 teaspoon treats 34 square feet 1 tablespoon treats 102 square feet
Karmex 80 WP....	1 teaspoon treats 48 square feet 1 tablespoon treats 144 square feet
Casoron 4G........	3½ ounces treats 100 square feet 2 pounds, 4 ounces treats 1,000 square feet

Suggestions and restrictions. Princep and Karmex: Apply to weed-free soil in the spring before berry plants leaf out. Do not apply to plants established less than one year. Make only one application per year.

Casoron: Apply in late fall, winter, or early spring to plants established at least 6 months. Make only one application per year.

Grapes

Grapes should be mulched or cultivated during the first three growing seasons. During the fourth and subsequent growing seasons, mulching or cultivation may be continued, or Karmex, Princep, or Casoron may be applied to a 3- to 4-foot wide strip down the row. Apply Karmex or Princep in the spring. Casoron should be applied in late fall, winter, or early spring. Paraquat may be applied during the growing season as needed for weed knockdown.

Princep 4G........	4½ ounces treats 100 square feet 3 pounds, 7 ounces treats 1,000 square feet
Princep 80 WP....	1 teaspoon treats 29 square feet 1 tablespoon treats 87 square feet
Karmex 80 WP....	1 teaspoon treats 38 square feet 1 tablespoon treats 114 square feet
Paraquat..........	See section on Paraquat (page 10)
Casoron 4G........	5½ ounces treats 100 square feet 3 pounds, 7 ounces treats 1,000 square feet

Strawberries

Immediately after planting, Dacthal can be applied. It is more effective against grasses than against broadleafed weeds and is effective for about six to eight weeks. When Dacthal loses its effectiveness, clean the patch by cultivation and hoeing and apply again or switch to Enide.

Enide has a much longer effective period than Dacthal and is likewise more effective against grass than against broadleafed weeds.

From planting time until runners start to form, many growers find cultivation and hoeing to be the most economical and successful weed control program. When the runner plants begin to root in late June or July, cultivation must be reduced; at this time, either Dacthal or Enide may be applied. If Dacthal is used, it can be applied again in September. If Enide is applied, it should be effective until late fall.

The effectiveness of Dacthal and Enide is destroyed by cultivation. After application of either of these materials, use a hand hoe or hand pulling to remove any weeds that were missed. Do not cultivate until just before you are ready to make another herbicide application.

In late November just before mulching, apply Enide. This application should give control through the harvest season. If dandelions and other perennial weeds are present, amine 2,4-D may also be applied.

At renovation time, immediately after harvest, when the rows have been narrowed and weeds in the aisles have been destroyed by cultivation, apply Dacthal or Enide. Enide should be effective until late fall. If Dacthal is applied, apply again in six to eight weeks. If broadleafed weeds are present in the rows at renovation time, amine 2,4-D may be applied.

Follow with an application of Enide just before mulching, as suggested above. In subsequent years, apply herbicides at renovation time and in late November before mulching.

Dacthal 5G	6½ ounces treats 100 square feet
	4 pounds treats 1,000 square feet
Dacthal 75 WP.....	1 teaspoon treats 16 square feet
	1 tablespoon treats 48 square feet
Enide 50 WP......	1 teaspoon treats 13 square feet
	1 tablespoon treats 39 square feet
Amine 2,4-D.......	See section on 2,4-D (page 11)

Suggestions and restrictions. Do not apply Dacthal when blossoms or berries are present. Do not apply Enide within 60 days before harvest, and do not apply more than twice a year. Amine 2,4-D may be applied immediately after harvest or in late fall but not at other times.

APPLYING WETTABLE POWDER RESIDUAL HERBICIDES

To be effective against germinating weeds without substantially injuring fruit plants, an exact amount of the herbicide must be spread evenly on an exact area of the soil. Recommendations for wettable powder herbicides in this circular give amounts in teaspoons or tablespoons to be spread evenly over square foot areas (length × width). For smaller areas, use ½ teaspoon or ¼ teaspoon measures and calculate the area to be covered by dividing the area for 1 teaspoon by 2 or by 4, respectively. For larger areas, multiples of 1 tablespoon may be used.

For most wettable powder applications a sprayer is the most convenient equipment. Use a flat fan type nozzle. For small areas a sprinkling can may be satisfactory.

The first step in application is adjusting the equipment to fit the situation. First, look up the amount of material required for a given area (see the section for each crop). Next, stake out the given area. If 1 tablespoon of material is suggested for 50 square feet, stake out an area of 50 square feet. Then make a trial run with the sprayer using water *only.* Try 1 quart of water. Spray evenly over the staked out area until all of the water is used. After the first trial run you may wish to increase or decrease the amount of water. After you have adjusted the amount of water to an amount convenient for covering the staked out plot, you are ready to apply the residual herbicide.

Measure the required amount of herbicide using a **measuring** teaspoon or tablespoon. Regular teaspoons and tablespoons used for eating and serving food do *not* measure accurately. Do not pack the material into the measuring spoon. Dip the measuring spoon into the material, overfilling the spoon. Then use a spatula or knife to remove the excess material, leaving the measuring spoon level full.

Place the measured amount of herbicide and the measured amount of water in the sprayer. Close the sprayer and shake vigorously to mix. Shake the sprayer while spraying to keep the materials mixed. Spray all of the material evenly on the staked out area.

Example: Applying Enide 50 WP to strawberries. The recommended rate is 1 tablespoon per 38 square feet. If the rows are 3½ feet wide, stake out an area 3½ feet by 11 feet. Make a trial run with water only, using 1 quart of water. If 1 quart of water is convenient for coverage of the staked out area, put 1 tablespoon of Enide 50 WP and 1 quart of water in the sprayer, shake thoroughly to mix, and spray evenly over the staked out area, using all of the spray mixture.

APPLYING GRANULAR RESIDUAL HERBICIDES

In granular formulations, the herbicide is incorporated onto an inert material and made into small granules. A fertilizer spreader or seeder is used to spread the material evenly over a specified area.

A lawn fertilizer spreader that drops the material in a band is convenient for applying granular materials under fruit trees and on strawberry beds. To calibrate this type of spreader, spread a sheet of plastic on a smooth area such as a driveway. Then run the spreader over a measured distance and determine the amount of material spread over the square foot area covered.

Example: Applying Dacthal 5G to strawberries. The recommended rate is 6½ ounces for 100 square feet or 4 pounds per 1,000 square feet. Set the dial for 4 pounds per 1,000 square feet; but since materials vary in density, test to determine the actual delivery rate. Spread a plastic sheet on the driveway, mark off 10 feet, and spread a 10-foot strip. Sweep up the material and weigh. If the material delivered weighed 3 ounces and the width of the band was 3 feet, then the rate was 3 ounces spread on 30 square feet (10 ft. long × 3 ft. wide). This would be a rate of 10 ounces per 100 square feet, which is too much. Reduce the size of the delivery holes and try another test strip. Continue adjusting and measuring delivery on the test strip until 2 ounces are delivered on the 30-square-foot test strip.

The cyclone-type spreader or seeder is more difficult to calibrate because walking speed is a part of the calibration. Rather than calibrate the spreader and speed of walking, a different approach is suggested. Set the opening to deliver the material slowly so that you must make two or more trips over the area to apply the given amount of material. Determine the number of square feet to be treated and calculate the amount of granular material needed. Put this amount of material in the spreader and go over the area to be treated until all of the material is used up.

APPLYING PARAQUAT AND 2,4-D

Paraquat

Use 1 tablespoon of Paraquat plus 1 teaspoon of a wetting agent per gallon of water. Wet the weed and grass foliage. Keep off foliage of fruit plants. The wetting agent may be a regular spreading agent or a liquid dishwashing agent such as Lux, Vel, etc. Paraquat may be applied more than once during the growing season.

Because Paraquat has been listed as a restricted pesticide by the Environmental Protection Agency, purchase and use are limited to certified private applicators.

2,4-D

Use 1 tablespoon of amine 2,4-D plus 1 teaspoon of wetting agent (see the preceding paragraph) per gallon of water. Wet the foliage of broadleafed weeds under apple and pear trees, but keep off apple and pear foliage. In strawberry beds, wet the foliage of both broadleafed weeds and strawberry plants.

Tomatoes and grapes are extremely sensitive to vapors from 2,4-D sprays. During the growing season, do not spray 2,4-D near these plants — keep at least 100 feet away.

PRECAUTIONS

1. Choose a calm day to apply herbicides. Winds cause drift to other plants and other areas and prevent even coverage.
2. Use low pressure in the tank or pump.
3. Use flat fan weed spray nozzles.
4. Read and follow all precautions listed on the product label.

This guide is provided for your information. The University of Illinois and its agents assume no responsibility for results from using herbicides.

This circular was prepared by Daniel B. Meador, Associate Professor of Pomology Extension, and C. Chris Doll, Area Extension Adviser in Fruits and Vegetables.

Chemical Control of Some Aquatic Plants

R. C. HILTIBRAN

Group and species	Chemical, active ingredient, or free acid equivalent	Rate of application	Remarks
EMERGENT PLANTS			
Arrowhead (*Sagittaria* spp.)	Use one of the following:		
	2,4-D		
	ester (20% G)	1 lb./440 sq. ft.	Spread on water
	ester (4 lb./gal.)	1/4 cup/2 gal.	Wet foliage
	amine (4 lb./gal.)	1/4 cup/2 gal.	Wet foliage
	silvex		
	ester (4 lb./gal.)	1/4 cup/2 gal.	Wet foliage
	potassium salt (6 lb./gal.)	1/4 cup/2 gal.	Wet foliage
	potassium salt (20% G)	1 lb./440 sq. ft.	Spread on water
	diquat cation (2 lb./gal.)	1/4 cup/gal.	Wet foliage
Bulrush (*Scirpus acutus*)	Use one of the following:		
	2,4-D		
	ester (20% G)	1 lb./440 sq. ft.	Spread on water
	ester (4 lb./gal.)	1/2 cup/2 gal.	Wet stems
	diquat cation (2 lb./gal.)	2 tbsp./3 gal. and 1 tsp. non-ionic wetting agent	Wet foliage to point of runoff
	dichlobenil (aquatic granules 4%)*	100 lb./A.	Apply in March to exposed bottom soil
Cattails (*Typha* spp.)	Use one of the following:		
	dalapon	4 oz./gal. and 3 caps detergent	Wet foliage
	amitrole	2 oz./gal. and 3 caps detergent	Wet foliage
	2,4-D ester (4 lb./gal.)	1/2 cup/gal. and 3 caps detergent	Wet foliage
	diquat cation (2 lb./gal.)	2 tbsp./3 gal. and 1 tsp. nonionic wetting agent	

*The formulation currently available may contain 10 percent dichlobenil; therefore, the amount of granular formulation used will have to be adjusted.

Group and species	Chemical, active ingredient, or free acid equivalent	Rate of application	Remarks
Creeping water primrose (*Jussiaea repens* var. *glabrescens*)	Use one of the following:		
	2,4-D		
	ester (20% G)	1 lb./440 sq. ft.	Spread on water
	ester (4 lb./gal.)	1/4 cup/2 gal.	Wet foliage
	amine (4 lb./gal.)	1/4 cup/2 gal.	Wet foliage
	silvex		
	ester (4 lb./gal.)	1/4 cup/2 gal.	Wet foliage
	potassium salt (6 lb./gal.)	1/4 cup/2 gal.	Wet foliage
	potassium salt (20% G)	2 lb./440 sq. ft.	Spread on water
	diquat cation (2 lb./gal.)	1/4 cup/2 gal.	Wet foliage
Spatterdock (*Nuphar advena*)	dichlobenil	6 lb.a.i./A. 3 lb.4% granules* per 440 sq. ft.	Spread on water
Waterwillow (*Justicia americana*)	Use one of the following:		
	2,4-D		
	ester (20% G)	1 lb./440 sq. ft.	Spread on water
	ester (4 lb./gal.)	1/4 cup/2 gal.	Wet foliage
	amine (4 lb./gal.)	1/4 cup/2 gal.	Wet foliage
	silvex		
	ester (4 lb./gal.)	1/4 cup/2 gal.	Wet foliage
	potassium salt (6 lb./gal.)	1/4 cup/2 gal.	Wet foliage
	potassium salt (20% G)	1 lb./440 sq. ft.	Spread on water
	diquat (2 lb./gal.)	1/4 cup/2 gal.	Wet foliage
SUBMERSED PLANTS WITH ALTERNATE LEAF ATTACHMENT			
Curlyleaf pondweed (*Potamogeton crispus*)	Use one of the following:		
	endothall (potassium salt, 4.23 lb./gal. or 10% G)	0.3 ppm (total or large-scale application) 1.0 ppm (marginal application)	Apply on or below surface
	diquat (2 lb./gal.)	0.5 ppm or 1 gal./surface A.	Same as above
	dichlobenil (aquatic granules 4%)	200 lb./A.	Preemergent application
	fenac	See manufacturer's directions	Must be applied to exposed pond bottom

*The formulation currently available may contain 10 percent dichlobenil; therefore, the amount of granular formulation used will have to be adjusted.

Group and species	Chemical, active ingredient, or free acid equivalent	Rate of application	Remarks
Curlyleaf pondweed (continued)	diquat/copper-triethanolamine complex	0.25 ppm diquat plus equal volume of copper-triethanolamine complex	Apply on or below water surface
	endothall (di(N,N-dimethylalkylamine)salt)(L)	0.5 ppm (endothall content)	Apply on or below water surface
	(10% G)	100 lb./A.	Spread on water
	simazine (80-WP)	0.5 ppm	Apply to total water volume
Leafy pondweed *(P. foliosus)*	Use one of the following:		
	endothall (potassium salt, 4.23 lb./gal. or 10% G)	0.3 ppm (total or large-scale application) 1.0 ppm (marginal application)	Apply on or below water surface
	diquat cation (2 lb./gal.)	0.5 ppm, or 1 gal./surface A.	Same as above
	dichlobenil (aquatic granules 4%)	300 lb./A.	Preemergent application*
	fenac (10% G)	See manufacturer's directions	Must be applied to exposed pond bottom
	endothall (di(N,N-dimethylalkylamine) salt) (10% G)	100 lb./A.	Spread on water
	simazine (80-WP)	0.5 ppm	Apply to total water volume
Sago pondweed *(P. pectinatus)*	Use one of the following:		
	endothall (potassium salt, 4.23 lb./gal. or 10% G)	0.3 ppm (total or large-scale application 1.0 ppm (marginal application)	Apply on or below water surface
	diquat cation (2 lb./gal.)	0.5 ppm, or 1 gal./surface A.	Same as above
	dichlobenil (aquatic granules 4%)	100 lb./A.	Preemergent application
	fenac (10% G)	See manufacturer's directions	Must be applied to exposed pond
	simazine (80-WP)	0.5 ppm	Apply to total water volume
Small pondweed *(P. pusillus)*	Use one of the following:		
	endothall (potassium salt, 4.23 lb./gal. or 10% G)	0.3 ppm (total or large-scale application) 1.0 ppm (marginal application)	Apply on or below water surface

*The preemergent herbicides have not given satisfactory season-long control of leafy pondweed.

Group and species	Chemical, active ingredient, or free acid equivalent	Rate of application	Remarks
Small pondweed (continued)	diquat cation (2 lb./gal.)	0.5 ppm	Same as above
	dichlobenil (aquatic granules 4%)	200 lb./A.	Preemergent application
	fenac (10% G)	See manufacturer's directions	Must be applied to exposed pond bottom
	endothall (di(N,N-dimethylalkylamine)salt) (10% G)	100 lb./A.	Spread on water
	simazine (80-WP)	0.5 ppm	Apply to total water volume
Waterstar grass *(Heteranthera dubia)*	diquat cation (2 lb./gal.)	1 ppm, or 2 gal./ surface A.	Apply on or below water surface
	endothall (potassium or 10% G)	5 ppm	Same as above
SUBMERSED AQUATIC PLANTS WITH OPPOSITE LEAF ATTACHMENT			
Buttercup *(Ranunculus* spp.)	diquat cation (2 lb./gal.)	0.5 ppm	Apply below water surface
Cabomba *(Cabomba caroliniana)*	endothall (di(N,N-dimethylalkylamine)salt)(L)	2 ppm	Same as above, small-scale application only
Slender naiad *Najas flexilis)*	Use one of the following:		
	diquat cation (2 lb./gal)	1 ppm, or 1.5 gal./ surface A.	Same as above
	endothall (potassium salt, 4.23 lb./gal. or 10% G)	3 ppm (total or large-scale application) 4 ppm (marginal application)	Same as above
	endothall (di(N,N-dimethylalkylamine)salt)(L)	2 ppm (endothall content)	Apply on or below water surface
	dichlobenil (aquatic granules 4%)	200 lb./A.	Preemergent application
Southern naiad *(N. guadalupensis)*	Use one of the following:		
	diquat cation (2 lb./gal.)	1 ppm, or 1.5 gal./ surface A.	Apply below water surface
	endothall (potassium salt, 4.23 lb./gal. or 10% G)	3 ppm (total or large-scale application) 4 ppm (marginal application)	Same as above

Group and species	Chemical, active ingredient, or free acid equivalent	Rate of application	Remarks
Southern naiad (continued)	endothall (di(N,N-dimethylalkylamine)salt)(L)	2 ppm (endothall content)	Apply on or below water surface
	dichlobenil (aquatic granules 4%)	200 lb./A.	Preemergent application
SUBMERSED AQUATIC PLANTS WITH WHORLED LEAF ATTACHMENT			
Coontail (*Ceratophyllum* ssp.)	Use one of the following:		
	endothall (potassium salt, 4.23 lb./gal. or 10% G)	2 ppm	Spread on water
	2,4-D ester (20% G)	2 ppm	Spread on water
	silvex ester (4 lb./gal.)	2 ppm	Spread on water
	diquat cation (2 lb./gal.)	1 ppm, or 2 gal./surface A.	Apply below water surface
	diquat/copper-triethanolamine complex	0.5 ppm diquat plus equal volume of copper-triethanolamine complex	Apply on or below water surface
Elodea (*Elodea canadensis*)	diquat cation (2 lb./gal.)	1 ppm, or 2 gal./surface A.	Apply below water surface
Watermilfoil (*Myriophyllum* spp.)	2,4-D ester (20% G)	2 ppm	Spread on water
	silvex		
	ester (4 lb./gal.)	2 ppm	Apply below water surface
	potassium salt (6 lb./gal.)	2 ppm	Apply below water surface
	potassium salt (20% G)	2 ppm	Spread on water
	endothall (potassium salt, 4.23 lb./gal.	3 ppm	Apply below water surface
	or 10% G)	3 ppm	Spread on water
	diquat cation (2 lb./gal.)	1 ppm	Apply below water surface
	dichlobenil (aquatic granules 4%)	240-375 lb./A. or 2.5-3.8 lb./400 sq. ft.	Spread on water
	fenac (10% G)	See manufacturer's directions	Must be applied to exposed pond bottom
FLOATING-LEAVED AQUATIC PLANTS			
American pondweed (*Potamogeton nodosus*)	Use one of the following:		
	endothall (10% G)	1 ppm	Spread on water
	endothall (4.23 lb. potassium salt/gal.)	1/2 cup/gal.	Apply to leaves

Group and species	Chemical, active ingredient, or free acid equivalent	Rate of application	Remarks
Waterlilies ((*Nymphaea* spp.)	dichlobenil	5 lb.a.i./A.	Spread on water
FREE-FLOATING AQUATIC PLANTS			
Duckweed (*Lemna minor*)	Use one of the following:		
	endothall (potassium salt, 4.23 lb./gal. or 10% G)	1 cup/4 gal.	Apply to leaves
	diquat cation (2 lb./gal.)	1 cup/4 gal.	Apply to leaves
	simazine (80-WP)	0.5 ppm	Apply to total water volume
Watermeal (*Wolffia* spp.)	simazine (80-WP)	1 ppm	Apply to total water volume
ALGAE			
Chara (has cylindrical, whorled branches and resembles, in form, some of the plants mentioned above) (*Chara* spp.)	Use one of the following:		
	dichlobenil (aquatic granules 4%)	100 lb./A.	Preemergent application only
	copper sulfate*	1 ppm	Postemergent
	endothall(di(N,N-dimethylalkylamine)salt) (10% G)	0.3 ppm	Postemergent
	Mariner**	15-25 lb./A.	Apply on water surface
Filamentous algae	copper sulfate*	1 ppm	Postemergent
	endothall(di(N,N-dimethylalkylamine)salt) (L)	0.3 ppm	Postemergent
	Mariner**	15 lb./A.	Spread on water
	simazine (80-WP)	0.5 ppm	Apply to total water volume

*Crystalline copper sulfate can be used, however there are several copper-containing formulations that contain copper-chelating compounds, which prevent the immediate precipitation of copper as copper carbonate. Check the label for instructions concerning their uses and rates of application. A lower rate of application of copper can be used with these latter formulations. Their copper contents may vary.

**A copper-containing formulation developed by the 3M Company.

Additional information:

"The Chemical Control of Some Aquatic Plants." Mimeographed leaflets A5-16, Section of Aquatic Biology, Illinois Natural History Survey, Urbana, Ill. 61801.

Aquatic Plants and their Control. Fishery Bulletin No. 4, Illinois Department of Conservation, Springfield, Ill. 61706.

Controlling Weeds in Noncrop Areas

Soil sterilization is the application of nonselective chemicals or nonselective rates of selective chemicals as a means of controlling all vegetation in an area. Soil sterilants may be used to control vegetation in noncrop areas such as parking lots, drive-in theaters, driveways, patios, and certain industrial sites.

Soil sterilants can be classified by their length of control. Those with little or no residual activity are the fumigants and the contact herbicides. Fumigants are volatile materials that can affect the viability of weed seeds as well as existing growth. Contact herbicides, such as paraquat, control only the existing vegetation that the spray contacts.

Amitrole, dalapon, 2,4-D, and DSMA give temporary control for four months or less. Semipermanent control is provided by some inorganic salts, such as sodium borate and sodium chlorate. Organic compounds that provide semipermanent control are the uracils (bromacil), substituted ureas (monuron, diuron, and tebuthiuron), and the triazines (atrazine, velpar, simazine, and prometone).

There are a variety of particular uses including the following: (1) beneath asphalt pavement prior to the asphalt application, (2) along railroads, (3) around buildings as a means of preventing the growth of weeds that are unsightly or present a fire hazard, and (4) along fences to control weeds. However, it may be preferable to establish desirable, competitive vegetation along a fence in order to discourage weed growth and to provide protective soil and wildlife cover. Short-term herbicides, such as 2,4-D and dalapon, might be used for temporary control until desirable vegtation can be established.

PRECAUTIONS AND GENERAL PROCEDURES

Several precautions must be observed when using nonselective chemicals. You must know what weeds are to be controlled and select the correct chemical for those particular problems. A survey of the area must be made, noting any desirable vegetation in the immediate or adjacent areas that could be affected by spray drift, chemical runoff, or leaching into the root zone.

Appropriate precautions should be taken to prevent damage to desirable plants. The risk of injury with some of these materials may be too great to allow their use in some areas. Be certain that you are familiar with the product and aware of the risks before using these materials. Some treatments should be made only by professional applicators.

The type of vegetation to be controlled will affect your decision in selecting a chemical. Perennial grasses can be controlled with dalapon, amitrole, or DSMA; woody perennials, with 2,4,5-T, silvex, or picloram. Deep-rooted vines, such as bindweed, can be controlled with fenac, 2,3,6-TBA, dicamba, or picloram.

Application time is very important. The best time to apply nonselective, soil-residual herbicides is early in the spring before herbaceous weeds have emerged. If vegetation is heavy, it may be necessary to remove existing vegetation or to add a contact or foliar herbicide to speed topkill. Mixing the herbicides with diesel fuel will also do this. After existing vegetation is under control, the rate can be reduced for maintenance applications in the future.

Adjust the application rates according to the soil types. Rates are also often adjusted for the desired length of control. When a span of two or three years is desired, maintenance applications are better than an initial application that is too high.

HERBICIDES FOR NONCROPLAND

Inorganic Compounds

1. *Sodium chlorate* has both foliar and root activity. However, there is an extreme *fire hazard* with this compound. Fire retardants, such as calcium chloride or the borates, are often added to reduce the hazard. Altacide is sodium chlorate with a fire retardant. Sodium chlorate may also be toxic to livestock that seek its salty taste. The rate is 500 to 1,000 pounds per acre.

2. *Sodium borate (concentrated Borascu)* has primarily root activity. Very high rates are required (1 to 2 tons per acre), so it is often used only as a granular carrier for organic compounds.

3. *Sodium arsenite* is a *highly toxic* compound. It is not usually recommended, since safer products are now available. Sodium arsenite is formulated as a 9.5-pound-per-gallon liquid. The rate is 55 to 110 gallons per acre.

4. *Ammonium sulfamate (Ammate-X)* is formulated as 95-percent soluble crystals for weed control on woody plants and herbaceous weeds. It is sometimes used for brush control where volatilization of phenoxy herbicides would be a hazard. Ammonium sulfamate is corrosive to metals. The rate is 60 to 100 pounds per acre.

Organic Compounds for Long-Term Control

1. *Bromacil (Hyvar-X)* has both foliar and soil activity. It is formulated as an 80-percent wettable powder (WP) and a 2-pound-per-gallon liquid. The rate of active ingredient is 5 to 15 pounds per acre. Urox B is a 4-pound-per-gallon liquid of bromacil.

2. *Bromacil + diuron (Krovar I)* is formulated as an 80-percent, 1:1 combination of bromacil:diuron. It is used to control shallow-germinating weeds and deep-rooted perennials. The rate is 6 to 30 pounds per acre. Krovar II is a 2:1, bromacil: diuron formulation.

3. *Simazine (Princep)* is formulated as an 80-percent wettable powder and a 4-percent granule. It has little foliar activity, but has a longer residual control than atrazine. The rate is 5 to 40 pounds per acre of the 80-percent wettable powder.

4. *Atrazine (AAtrex)* is an 80-percent wettable powder. Atratol 8P is 8-percent atrazine on a chlorate-borate granule. The rate 5 to 40 pounds per acre of the 80-percent wettable powder or 1/4 to 1 pound per 100 square feet of the pelleted formulation.

5. *Prometone (Pramitol)* is available as a 2-pound-per gallon liquid and as a 5-percent pellet. It has more foliar activity than atrazine. The rate is 5 to 30 gallons per acre or 1/2 to 2 pounds of the pellets per 100 square feet.

6. *(Velpar)* is a 90-percent water soluble powder. Apply 2 to 5 pounds per acre for contact kill and short-term control or 6 to 12 pounds per acre for season-long control.

7. *Tebuthuiron (Spike)* is available as an 80-percent wettable powder. Apply before or during periods of active growth at a rate of 5 to 20 pounds per acre.

8. *Diuron (Karmex)* is an 80-percent wettable powder. The rate is 10 to 60 pounds per acre. It is sometimes mixed with bromacil (see No. 2).

9. *Dichlobenil (Casoron)* is available as a 50-percent wettable powder and a 4-percent pellet. It is more commonly used for nursery weed control than for soil sterilization. The rate is 10 to 40 pounds per acre of the 50-percent wettable powder.

10. *Amizine* is a combination of amitrole and simazine, bringing together the foliar activity of amitrole with the residual activity of simazine. The suggested rate for general vegetation control is 20 pounds of Amizine in 100 gallons of water per acre.

11. *Urox,* a combination of monuron and TCA, is available as an 11-percent and a 22-percent pellet and as a 3-pound-per-gallon liquid. Urox combines the grass control of TCA with the residual control of monuron.

Many of the granular or pelleted materials are organic herbicides formulated on sodium borate or borate-chlorate granules. They can be applied dry, which is often convenient for spot treatment or application on small areas.

1. Chlorea is monuron on a chlorate-borate base.

2. Ureabor is 1.5 percent bromacil on sodium-borate pellets. Amoco Industrial Weed Killer B is also bromacil on a chlorate-borate pellet.

3. Atratol 8P is 8 percent atrazine on a borate-chlorate base.

4. Pramitol 5P is prometone on a borate-chlorate pellet.

5. Benzabor is 2,3,6-TBA on a borate granule.

Organic Herbicides for Short-Term Control

1. *Amitrole* is available as Weedazol and Amino Triazole. Amitrole is a translocated herbicide that is especially effective on poison ivy and some strains of Canada thistle. It can provide control of some perennial grasses such as quackgrass. Amitrole is a 90-percent soluble powder, and is applied at a rate of 4 to 8 pounds per acre as a spray.

2. *Amitrole-T* is available in liquid form as Cytrol and Amitrol-T with 2 pounds per gallon of amitrole plus ammonium thiocyanate. Since amitrole-T is formulated as a liquid, it is sometimes considered more convenient to handle than amitrole. The rate is 1 to 3 gallons per acre.

3. *Dalapon (Dowpon-M, Basfapon)* is a foliar-applied, translocated grass killer. Dalapon is available with TCA (Dowpon-C) for longer residual control. The rate is 10 to 15 pounds per acre of the 85-percent soluble powder. A wetting agent improves the control. Perennial grass may require more than one application.

4. *Sodium-TCA* is a root-absorbed grass killer than remains in the soil longer than dalapon. It is a 90-percent soluble powder used at 50 to 150 pounds per acre.

5. *MSMA* is available as Daconate, a 6-pound-per-gallon liquid with surfactant. MSMA is used for perennial grass control at 0.5 to 1.5 gallons per acre. More than one application may be necessary.

6. *DSMA* is available in two forms, liquid or soluble powder. DSMA is frequently used for spot treatment of johnsongrass. The rate is 3 to 9 pounds per acre of the soluble powder or 1 to 2 gallons per acre of the liquid.

7. *Paraquat* is a 2-pound-per-gallon contact herbicide with little residual activity. The volume of water should be adjusted to the amount of vegetation. The rate is 1 to 3 quarts per acre. A surfactant is added at the time of application.

8. *Glyphosate (Roundup)* is available as a 4-pound-per-gallon contact herbicide that is nonpersistent. Unlike paraquat, it will translocate to kill perennial weeds. The rate is 1 to 5 quarts per acre.

9. *Dinoseb ("dinitro")* is a contact herbicide often mixed with fuel oil. Dinoseb is *quite toxic* and will stain clothes and skin. Mix 1 to 2 quarts per 30 to 50 gallons of fuel oil with enough water to make a total volume of 100 gallons.

HERBICIDES FOR BROADLEAF WEED AND BRUSH CONTROL

1. *Dicamba (Banvel)* is available as a 4-pound-per-gallon formulation. Banvel presents a hazard to nearby soybeans, tomatoes, and desirable woody plants. The application rate is 1 to 4 quarts per acre.

2. *Picloram (Tordon)* is a persistent, broadleaf herbicide. It is formulated as a liquid with 2,4-D as Tordon 212 and on a borate pellet as Tordon 22K and Borolin. Special care must be taken because of its long soil life and mobility in the soil.

3. *2,3,6-TBA* is a benzoic acid herbicide available as Benzac 1281 and Trysben 200. This compound is used to control deep-rooted, perennial broadleaf weeds. It is formulated as a 2-pound-per-gallon liquid and is applied at 2 to 10 gallons per acre. Considerable precaution should be taken to avoid injury to nearby desirable plants.

4. *Fenac* is closely related to 2,3,6-TBA in terms of controlling deep-rooted, perennial broadleaf weeds. It is formulated as a 1.5-pound-per-gallon liquid. The application rate is 2 to 15 gallons per acre.

5. *2,4,-D* is a broadleaf herbicide with short persistence. Amine formulations present less hazard to nearby, sensitive plants than ester forms. The common formulation is as a 4-pound-per-gallon liquid. Mixtures of 2,4-D and dalapon are often used for short-term control of both broadleaf and grass weeds.

6. *2,4,5-T* is similar to 2,4-D, but gives better control of some woody plants and has a longer soil life. Mixtures of 2,4-D and 2,4,5-T are commonly called "brushkiller." The common formulation is as a 4-pound-per-gallon liquid. Current restrictions (1973) forbid the use of 2,4,5-T around homes or on lakes, ponds, and ditchbanks.

7. *Silvex (Kuron, 2,4,5-TP)* may be used for control of brush in a manner similar to 2,4,5-T. Silvex has had fewer restrictions on where it can be used.

8. *Bromacil (Hyvar-XL)* is a 2-pound-per-gallon liquid for basal spraying of brush. A 10-percent pellet (HABCO-10B) is also available.

9. *Krenite* is available as a 4-pound-per-gallon formulation. When it is applied within two months of leaf senescence, no symptoms are evident until the following spring. Because it does not translocate, it can be used for chemical trimming. The rate is 1-1/3 to 3 gallons per acre.

LONG-TERM RESIDUAL CONTROL

Spray Applications

Many of these chemicals are wettable powders and will require thorough agitation for spray application. The rates listed are for the different types of weeds to be controlled. Initial applications are often made at the high rate, with subsequent treatments at the lower rate.

	Rate of formulation per acre		
Herbicide	Annuals	Shallow perennials	Deep perennials
AAtrex (80 pct.).	6 to 12.5 lb.	12.5 to 25 lb.	25 to 50 lb.
Amizine	6 lb.	12 lb.	20 lb.
Casoron (50 pct.)	8 to 12 lb.	12 to 25 lb.	25 to 40 lb.
Hyvar-X (80 pct.)	3 to 6 lb.	7 to 12 lb.	15 to 30 lb.
Hyvar-X-L (2 lb./gal.). .	1 to 2 gal.	3 to 6 gal.	6 to 12 gal.
Karmex (80 pct.).	8 to 20 lb.	20 to 40 lb.	20 to 60 lb.
Krovar I (80W).	2 to 6 lb.	7 to 18 lb.	14 to 40 lb.
Pramitol 25E (2 lb./gal.)	5 to 7.5 gal.	7.5 to 15 gal.	15 to 30 gal.
Princep (80 pct.)	6 to 12.5 lb.	12.5 to 25 lb.	25 to 50 lb.
Sodium chlorate	300 to 500 lb.	500 to 750 lb.	750 to 1,300 lb.
Spike (80 pct.)	5 to 10 lb.	10 to 20 lb.	...
Velpar (90 pct.).	2 to 5 lb.	6 to 12 lb.	...

Granular or Pellet Application

Granulars are often more convenient for spot treatment and for small areas. Many granules are on a sodium chlorate-borate base.

Herbicide	Number of pounds per: 100 square feet	square rod
Atratol 8P	0.5 to 1	2 to 3
Benzabor	0.5 to 0.5	1 to 2
Casoron-10P	0.5 to 1	3 to 5
Chlorea-3 (3 pct. monuron + borate-chlorate)	1 to 2	3 to 5
Concentrated Borascu	4 to 6	12 to 15
Pramitol 5P	1 to 2	3 to 5
Sodium chlorate	1.5 to 3	4 to 6
Sodium chlorate-borate	3 to 4	8 to 10
Sodium chlorate-modified	2 to 4	6 to 10
Ureabor	2 to 4	6 to 9

BROADLEAF WEEDS

These are often best controlled with foliar applications. Deep-rooted perennials can usually be controlled best when they are at the early bud to early bloom stage. The materials listed below can move through the air and damage nearby desirable broadleaf plants. They are quite soluble and mobile in the soil, and can move into the soil and damage trees or other desirable shrubs and broadleaf plants.

Herbicide	Rate of formulation per acre: Annual and shallow perennials	Deep-rooted perennials
Banvel (dicamba)	0.5 to 1 qt.	1 to 4 qt.
Fenac	2 to 5 gal.	10 to 15 gal.
Silvex	1 to 2 qt.	2 to 4 qt.
Tordon 212 (picloram + 2,4-D)	2 to 4 qt.	4 to 12 qt.
2,3,6-TBA	2 to 5 gal.	5 to 20 gal.
2,4-D and/or 2,4,5-T	1 to 2 qt.	2 to 4 qt.

UNDESIRABLE WOODY PLANTS

Most of the materials used to control such plants are applied to the foliage, but can be applied (1) as basal bark treatments if the trees are less than 3 inches in diameter or (2) as a frilled treatment if the trees are larger. The basal treatment can be applied during the dormant season in fuel oil. Foliar treatments are usually applied as soon as the brush or trees have leaves fully expanded.

Herbicide	Method of application	Rate of formulation
Ammate-X (ammonium sulfamate)	Foliar	60 lb./A.
Banvel (4 lb./gal. dicamba)	Foliar	2 to 4 qt./A.
Habco 10B (10 pct. bromacil)	Soil	1 to 2 tbsp./sq. ft.
Krenite	Foliar	1-1/3 to 3 gal./A.
Silvex	Foliar or basal	2 to 4 qt./A.
Tordon 212 (picloram + 2,4-D)	Foliar or basal	1 gal./A.
2,4-D and/or 2,4,5-T	Foliar or basal	2 to 4 qt./A.

WEEDY GRASS CONTROL

Weedy grass control is often best accomplished with the herbicides listed below. The use of a spreader-sticker (surfactant) often helps.

Herbicide	Rate of formulation per acre	
	Annuals	Perennials
Ansar 529HC.	1 to 2 qt.	2 to 4 qt.
Cytrol, Amitrol-T.	1 gal.	2 to 3 gal.
Daconate	2 to 3 qt.	3 to 5 qt.
Dowpon	5 to 10 lb.	10 to 30 lb.
Glytac (TCA ester)	2.5 gal.	5 gal.
Roundup.	1 to 2 qt.	2 to 5 qt.
Sodium-TCA	20 to 50	100 to 150

CONTACT WEED CONTROL

Contact herbicides kill the plant tissue with which they come in contact; thus, adquate spray volume is needed for full coverage. The use of a surfactant often helps the spray to spread on the plants.

Herbicide	Rate per acre
Fuel oil + dinoseb. . .	50 gal. + 2 qt.
Herbicidal naphtha. . .	30 to 50 gal.
Paraquat.	1 to 3 qt./A.

COMMENTS

Availability, formulations, trade names, and federal clearance for the use of herbicides change from time to time. Always refer to the most recent product labels for precautions, directions for use, and rates to use. Use herbicides with appropriate precautions to avoid injury to desirable vegetation, to protect the user, and to assure the safety of humans and animals. Store herbicides properly so that children and those who may not be responsible for their actions do not have access to them. Store herbicides only in the original, well-marked containers. Properly dispose of used herbicide containers and old herbicides.

There are both benefits and risks associated with the use of herbicides. Used properly, the benefits can far exceed the risks, and the quality of our environment can be improved by controlling undesirable vegetation. Do not neglect the opportunities for using desirable vegetation to compete with and replace undesirable vegetation. For some areas, mechanical control may sometimes be quite practical and the most appropriate method.

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The Toxicity of Herbicides

Toxicity is the capacity of a substance to produce injury. The toxic action of greatest concern is the lethal dosage (LD). This action can be immediate (acute) or it can be accumlative (chronic). Results of tests with animals show that toxicity of a given substance varies with species, age, sex, and nutritional status of the animal and also with the route of administration (internal--stomach, lungs; or external--dermal).

Before companies are granted clearances, they are required to do so several types of toxological tests on their compounds. They conduct mutagenic and teratogenic tests by progeny and litter testing. They also conduct acute, subacute, and chronic toxicity tests. One of the most useful expressions of acute lethal toxicity is the LD_{50}. LD_{50} represents the average lethal dosage (LD) per unit of body weight required to kill one-half (50 percent) of a large test population. Toxicity must, of necessity, be tested on animals rather than people. This creates some question when the results are applied to humans.

The usual test animals are white rats, but mice, rabbits, and dogs are sometimes used. The most common LD_{50} expression represents the acute oral toxicity, that is, the single internal dosage necessary to kill one-half of the test animals. The acute oral toxicity has limitations because it represents only the immediate toxicity of an internal dosage and not the chronic, accumulative effects of any skin absorption or irritation. Few herbicides, however, are absorbed rapidly through the skin, and most herbicides do not accumulate in the body to a toxic level. Some, however, such as Ramrod, do cause skin irritation.

LD_{50} values are expressed in terms of milligram of chemical per kilogram of body weight (mg/kg). Some conversion factors to convert common terms are as follows:

1 ounce = 28.38 grams = 28,380 milligrams
1 kilogram = 1,000 grams = 2.2 pounds
mg/kg x 0.0016 = ounces/hundredweight or $\frac{mg/kg}{625}$ = ounces/hundredweight
mg/kg x 0.0030 = ounces/180 pounds

Therefore an LD_{50} of 1,000 mg/kg would be 3 ounces of material per 180 pounds of body weight, while LD_{50} values of 100 and 10 would be 0.30 and 0.03 ounce per 180 pounds respectively. Since toxicities depend on body weight, it would take only one-third of this amount to be lethal to a 60-pound child and five times as much to kill a 900-pound animal.

The LD_{50} values are expressed on the basis of active ingredient. If a commercial material is only 50 percent active ingredient, it would take two parts of the mateerial to make one part of the active ingredient. In some cases chemicals mixed with the active ingredient (adjuvants) for formulating a pesticide may cause the toxicity to differ from that of the active ingredient alone. For example, the LD_{50} of 2,4-D acid is 320 mg/kg, while those of the ester formulations are 500 to 600.

The persistence of herbicides is an important factor in herbicide toxicity. A relatively toxic material that is not easily broken down is potentially more hazardous than one that decomposes rapidly after application. Soil persistence of herbicides is discussed in Agronomy Facts No. W-22a.

Sodium arsenite is one of the most toxic herbicides. It is a relatively old material that has been quite effective as a sterilant. It would be advisable, especially around the house, to use more recent, less toxic materials wherever possible. Sodium arsenite has caused more deaths than any other herbicide.

Pesticides must be handled and stored carefully. Pesticides should be stored only in properly labeled original containers. They should be kept where children cannot reach them. Empty containers should be destroyed or disposed of where children and animals cannot find them. Though the LD_{50} of some herbicides indicates a relatively low toxicity, it is well to form the habit of handling *all* pesticides carefully.

Proper precautions should be taken where livestock graze treated areas or are fed crops from treated areas. Although a certain herbicide may not be very toxic to animals, some residue may occur in the meat or milk. Treated pastures should not be grazed by dairy animals for 7 days after they have been treated with 2,4-D. Questions associated with 2,4-D toxicity in forage or food crops are discussed in Fact Sheet W-23.

The acute oral LD_{50} values for the active ingredient of some common herbicides are given in Agronomy Facts No. W-38, *Herbicides, Formulations, and Toxicities*. Remember: *The lower the LD_{50} value, the greater the toxicity.* A common standard for comparison is aspirin, which has an LD_{50} of 1,200 mg/kg or table salt which has 3,320.

The toxicity ratings for the various LD_{50} values are as follows:

Rating	*LD_{50}*	*Probable lethal dose for man*
Highly toxic	1-50	A few drops to 1 teaspoon
Moderately toxic	50-500	1 teaspoon to 2 tablespoons
Slightly toxic	500-5,000	1 ounce to 1 pint
Practically nontoxic	5,000-15,000	1 pint to 1 quart
Relatively harmless	15,000+	1 quart +

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PERSISTENCE OF HERBICIDES IN SOIL

The soil persistence of a herbicide is the length of time it remains active in the soil, that is, its active life. Farmers must consider persistence in using both preemergence and soil sterilant herbicides. Since preemergence herbicides are used to a greater extent than soil sterilants, our discussion here will be limited to preemergence herbicides.

Long persistence is desirable when it allows season-long weed control. However, when it extends past the growing season, it leaves a carryover or residual toxicity that may damage succeeding susceptible crops. Persistence therefore involves not only length of weed control, but also the possibility of soil residues.

It is sometimes desirable to have long persistence, especially in corn planted early in wide rows. The corn then does not grow so high or shade the weeds so fast as it ordinarily would. A longer period of weed control is therefore essential. The rows are shaded more rapidly in narrow-row culture than in wide-row culture. In narrow-row culture, so long as the initial control is adequate, the herbicide rate may possibly be reduced, since long persistence is not needed.

Anything that affects the rate of disappearance or loss of activity of a herbicide will affect its persistence. Soil, climatic, and herbicidal properties all have such an effect.

The soil factors may be divided into three categories--physical, chemical, and microbial. The physical conditions are soil composition (sand, silt, clay, and organic matter content), moisture-air relationships, and soil temperature. The chemical properties are pH, cation exchange capacity, and kind of clay. The microbial properties are the kind and amount of microorganisms plus the microbial environment, which consists of nutrients, temperature, and moisture. The climatic variables are primarily moisture, air temperature, and sunlight. The properties of the herbicide that affect its persistence are water solubility, vapor pressure, and susceptibility to chemical or microbial alteration or degradation.

Because the application rate and uniformity of distribution affect the concentration of the herbicide at a given place, accurate calibration and even distribution are essential. You must know how much <u>to</u> apply and how much you <u>do</u> apply.

The processes that are involved in decreasing the persistence of a herbicide are (1) volatility, (2) photodecomposition, (3) adsorption, (4) leaching, (5) plant uptake, (6) microbial decomposition, and (7) chemical decomposition.

Volatility is the process whereby the herbicide changes from a solid or liquid to a gas. It is associated with the vapor pressure of the chemical and increases with temperature. Photodecomposition is the breakdown of the herbicide by sunlight; thus the extent of exposure to sunlight is the primary variable. If a herbicide is subject to appreciable losses by either or both of these processes, then incorporation may help to reduce the loss. Such chemicals as Eptam and Vernam are incorporated because of their volatility.

Adsorption is the process whereby the herbicide is bound to the surface of a soil clay or organic matter particle. The strength and extent of the binding and the ease with which the material is replaced or released will affect the rate needed to control weeds and also its persistence in a given soil. Soils vary greatly in their adsorptive capacity, depending on the kind and amount of clay and organic matter. Herbicides that are adsorbed to a large extent are atrazine, Lorox, and Treflan; thus their rates of application must be adjusted to conform with the soil type.

Leaching occurs when a herbicide is dissolved in water and moves down through the soil profile. The primary factors involved in leaching are the amount of available water, the soil texture, the water solubility of the herbicide, and the degree of adsorption of the herbicide. A small amount of leaching is desirable to move the herbicide from the soil surface into the top 1 or 2 inches of soil, where most weed seeds germinate. If the herbicide leaches past the area of germinating weed seeds into the area of germinating crop seeds, then the crop may be injured if its tolerance is not adequate. On the other hand, herbicides that have low water solubility and that are strongly adsorbed may never reach the desired zone without adequate rainfall or incorporation.

Plant uptake, that is, adsorption of the herbicide by the plant roots, reduces the concentration of the herbicide in the soil. The persistence may be less if the herbicide is broken down (metabolized) by the plant or if the top growth is harvested and removed from the field. Thus, for example, if atrazine is applied at the same rate in a heavy quackgrass infestation as in a light infestation, the persistence will be less in the heavy infestation.

Microbial decomposition occurs when the soil microorganisms utilize the herbicide as a source of food or energy. Herbicides vary greatly in their susceptibility to microbial decomposition. If the right kind and number of microorganisms are present and if soil conditions are favorable for the microorganisms, then a herbicide may be rapidly decomposed in the soil. Thus, for example, 2,4-D lasts only a short time in the soil, while atrazine degradation is quite slow.

Chemical decomposition occurs as hydrolysis, oxidation, reduction, and other chemical reactions. Many soil chemical and physical conditions, such as moisture, aeration, pH, temperature, and organic matter content, regulate the rate of chemical and microbial decomposition.

Since many factors and processes are involved in the persistence of a preemergence herbicide, it is impossible to give the exact length of persistence for a particular herbicide. The approximate time can be estimated for a given set of conditions. The table on the next page shows the approximate length of active life of present corn and soybean preemergence herbicides at commonly applied rates. These values are estimated for average Illinois conditions.

Average Persistence of Herbicides[1]

Name: Trade	Name: Generic[2]	Rate lb. a.i./A	Time[3]	No. months of persistence
AAtrex	atrazine	1 to 4	PPI, PrE, PoE	2 to 8
Alanap	naptalam	2 to 8	PrE	1 to 1-1/2
Amiben, Vegiben	amiben	2 to 3	PrE	1-1/2 to 2
	amitrole	2 to 10	PoE	1/2 to 1
Balan	benefin	3/4 to 1-1/2	PPI	4 to 5
Banvel	dicamba	1/4 to 4	PrE, PoE	3 to 12
Basagran	bentazon	1/2 to 1½	PoE	0 to 1
Basalin	fluchloralin	1/2 to 1-1/2	PPI	3 to 6
Bladex	cyanazine	1 to 4	PrE, PPI, PoE	2 to 3
Caparol	prometryne	1 to 3	PrE	2 to 4
Casoron	dichlobenil	2 to 6	PrE, PoE	2 to 6
Cobex	dinitramine	1/3 to 2/3	PPI	2 to 4
Dacthal	DCPA	6 to 10	PrE	2 to 3
Dowpon	dalapon	5 to 10	PoE	1/2 to 1
Dual	metolachlor	2 to 4	PPI, PrE	1 to 3
Enide	diphenamid	4 to 6	PrE	3 to 6
Eptam, Eradicane	EPTC	2 to 4	PPI	1-1/2 to 3
Evik	ametryn	1½ to 2	PoE	1 to 3
Furloe, Chloro IPC	chlorpropham	2 to 8	PrE	1/2 to 1
Hyvar-X	bromacil	4 to 20	PrE	2 to 18
Igran	terbutryn	1.2 to 2.4	PrE, PoE	1 to 3
Karmex	diuron	2 to 4	PrE	3 to 6
Kerb	pronamide	1 to 2	PrE	2 to 9
Lasso	alachlor	2 to 4	PPI, PrE	1 to 2
Lorox	linuron	1/2 to 3	PrE, PoE	2 to 4
Maloran	chlorbromuron	1 to 6	PrE, PoE	2 to 4
Milogard	propazine	1 to 2	PrE	12 to 18
Modown	bifenox	1-3/5 to 2	PrE	1 to 2
Paraquat	paraquat	1/2 to 1	PoE	0 to 1/2
Pramitol	prometone	10 to 25	PrE	2 to 18
Premerge	dinoseb (dinitro)	6 to 9	PrE, PoE	0 to 1/2
Prefar, Betasan	bensulide	4 to 6	PrE	2 to 4
Princep	simazine	1 to 4	PPI, PrE	2 to 8
Prowl	penoxalin	1 to 2	PPI, PrE	2 to 6

Name		Rate		
Trade	Generic[2/]	lb. a.i./A	Time[3/]	No. months of persistence
Pyramin.	.pyrazon.	2 to 4	PrE	1 to 2
Ramrod, Bexton . . .	.propachlor	4 to 6	PrE	1 to 1-1/2
Roundup.	.glyphosate	1 to 4	PoE	0 to 1/2
Sencor, Lexone . . .	.metribuzin	1/8 to 1	PrE	1 to 4
Sinbar	.terbacil	1 to 8	PoE	5 to 6
Surflan.	.oryzalin	3/4 to 1-1/2	PrE	3 to 6
Sutan+	.butylate	2 to 4	PPI	1-1/2 to 2
Tenoran.	.Chloroxuron.	1-1/2 to 3	PoE	1 to 3
Tillam	.pebulate	3 to 5	PPI	1-1/2 to 2
TOK	.nitrofen	3 to 6	PoE	1 to 2
Tolban	.profluralin.	1/2 to 1	PPI	3 to 6
Tordon	.picloram	1/4 to 2	PoE	2 to 18
Treflan.	.trifluralin.	1/2 to 1	PPI	3 to 6
Tupersan	.siduron.	2 to 12	PrE	1 to 3
Vernam	.vernolate.	2 to 4	PPI, PrE	1 to 2
	2,4-D.	1/2 to 2	PoE	1 to 2
	2,4,5-T.	1/2 to 4	PoE	2 to 4
	silvex	1/2 to 4	PoE	2 to 4

1/ Normal Illinois conditions, medium-textured soil.
2/ Generic equals the coined name approved by the Weed Science Society of America.
3/ PPI equals preplant incorporated; PrE, preemergence; PoE, postemerge

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Herbicides, Formulations, and Toxicities

Generic name[a] (producer)	Trade name[b]	Concentration and commercial formulation[c]	Acute oral LD_{50}[d]
acrolein (Shell)	Aqualin	92% technical liquid	46
alachlor (Monsanto)	Lasso	4 lb/gal Ec 15% G	1,200
AMA (Cleary, Vineland)	(several)	16% solution	600
ametryne (CIBA-Geigy)	Evik	50, 80% WP	1,110
amitrole (American Cyanamid) (Amchem)	Amino-Triazole Amizol Weedazol	50, 90% WSP 2 lb/gal WSC	14,700-24,600
amitrole and simazine (Amchem)	Amizine	15% amitrole 45% simazine WP	
Amitrole-T (Amchem) (American Cyanamid)	Amitrole-T Cytrol	2 lb/gal WSC	5,000
atrazine (CIBA-Geigy)	AAtrex	8% G 80% WP 4 lb/gal WDL	3,080

[a]Weed Science Society of America-approved name, or experimental number.
[b]"Several" indicates many trade names.
[c]EC means emulsifiable concentrate; G, granules; WSP, water-soluble powder; WP, wettable powder; WSC, water-soluble concentrate; WSS, water-soluble salt; WDL, water-dispersable liquid; L, liquid; WSL, water-soluble liquid.
[d]LD_{50}--milligrams of chemical per kilogram of body weight which is lethal to 50 percent of the test animals, usually white rats, when administered in a single, oral dose.

Generic name[a] (producer)	Trade name[b]	Concentration and commercial formulation[c]	Acute oral LD_{50}[d]
atrazine and propachlor		6 2/3% atrazine 13 1/3% propachlor G	
(CIBA-Geigy)	AAtram	48.1% propachlor	
(Monsanto)	Ramrod/atrazine	20.9% atrazine WP	
benefin		1.5 lb/gal EC	5,000
(Elanco)	Balan	2.5% G	
bensulide		4 lb/gal EC	770
(Stauffer)	Betasan Prefar	3.6,7 & 12.5% G	
bentazon		4 lb/gal WSS	
(BASF)	Basagran		1,100
bifenox		80% WP	
(Mobil)	Modown		6,400
boron compounds	(several)	(various)	~2,000
bromacil		80% WP	5,200
(DuPont)	Hyvar-X	3 lb/gal EC 10% G	
bromoxynil		2 lb/gal EC	260-440
(Rhodia)	Buctril	75% WP	
(Amchem)	Brominal	5% G	2618
buthidazole (Velsicol)	Ravage	10% pellet	
butylate			
(Stauffer)	Sutan +	6.7 lb/gal EC	3,880
cacodylic acid Diamond	(several)	3.25, 2.48, & 5.7 lb/gal L 65% WSP	830
calcium arsenate	(several)	(granular and water suspension)	35-110
chloramben		2 lb/gal WSL	3,500
(Amchem)	Amiben Vegiben	10% G	
chlorbromuron		50% WP	2,150
(CIBA-Geigy)	Maloran		
chloroxuron		50% WP	3,700
(CIBA-Geigy)	Tenoran		
chlorpropham	Furloe	10 & 20% G	3,800
(PPG Industries)	Chloro IPC	3 & 4 lb/gal EC	
copper sulfate	(several)	(various)	300

Generic name[a] (producer)	Trade name[b]	Concentration and commercial formulation[c]	Acute oral LD_{50}[d]
cyanazine (Shell)	Bladex	80% WP 15% G 4 lb/gal WDL	334
cycloate (Stauffer)	Ro-Neet	6 lb/gal EC 10% G	3,160
dalapon (Dow)	Dowpon M	74% WSP	7,570-9,330
dalapon and TCA (Dow)	Dowpon C	46.5% dalapon 26.2% TCA WSP	
DCPA (Diamond Shamrock)	Dacthal	75% WP 5% G	3,000
dicamba (Velsicol)	Banvel	4 lb/gal	1,040
dichlobenil (Thompson-Hayward)	Casoran	50% WP 4,7.5 & 10% G	3,160
diclofop-methyl (Hoechst)	Hoelen	36% EC	580
dinitramine (U.S. Borax)	Cobex	2 lb/gal EC	3,700
dinoseb (DNBP) (Dow) (Niagara)	 Premerge Sinox	3 lb/gal WSL	58
diphenamid (Elanco) (Tuco)	 Dymid Enide	80% WP	830-1,110
diquat (Chevron)	Diquat	2 lb/gal aqueous solution	230-400
diuron (DuPont)	Karmex	80% WP 28% L	3,400
DSMA (Diamond Shamrock)	(several)	3 lb/gal WSC various WSP	600
endothall (Pennwalt)	Endothal Aquathol Hydrothal	(various EC & G)	182-206
EPTC (Stauffer)	Eptam Eradicane	7 lb/gal EC 2,3,4 & 10% G 6.7 lb/gal EC	1,370
ethalfluralin (Elanco)	Sonalan	3 lb/gal EC	10,000+

Generic name[a] (producer)	Trade name[b]	Concentration and commercial formulation[c]	Acute oral LD_{50}[d]
fluchloralin		4 lb/gal EC	1,550
(BASF)	Basalin	5% G	
glyphosate		3 lb/gal WSS	4,900
(Monsanto)	Roundup		
isopropalin		6 lb/gal EC	3,000
(Elanco)	Paarlan		
linuron		50% WP	1,500
(DuPont)	Lorox		
MCPA		2 & 4 lb/gal EC	700
(Rhodia)	Chiptox	20% G	
(Amchem)	MCPA		
MCPB		3.2 lb/gal EC	700
(Rhodia)	Can-Trol	2 lb/gal WSC	
(Amchem)	Thistrol		
MCPP		2.5 & 4 lb/gal EC	650
(Cleary)	Cleary's MCPP		
(Rhodia)	Chipco Turf Herbicide MCPP		
metolachlor (CIBA-Geigy)	Dual	8 lb/gal EC	2,828-4,286
metribuzin		50% WP	1,940
(Chemagro)	Sencor	42	
(DuPont)	Lexone		
monuron-TCA		(various G and L)	2,300
(Allied Chemical)	Urox		
MSMA	(several)		
(Diamond Shamrock)		(various L)	700
nitrofen		2 lb/gal EC	1,470
(Rohm & Hass)	TOK	50% WP	
napthalam (NPA)		2 lb/gal EC	1,770
(Uniroyal)	Alanap	10% G	
naptalam and dinoseb		2 lb/gal + 1 lb/gal EC	
(Uniroyal)	Dyanap		
(Ansul)	Ancrack		
(Thompson-Hayward)	Klean-Krop		
oryzalin		75% WP	10,000
(Elanco)	Surflan		
oxadiazon		40% EC	8,000
(Rhodia)	Ronstar	75% WP	

Generic name[a] (producer)	Trade name[b]	Concentration and commercial formulation[c]	Acute oral LD_{50}[d]
oxyflurafen (Rohm & Haas)	Goal	2 lb/gal EC	5,590-6,010
paraquat (Chevron)	Paraquat	2 lb/gal WSS	120
pebulate (Stauffer)	Tillam	6 lb/gal EC 10% G	920
pendimethalon (American Cyanamid)	Prowl	4 lb/gal EC	1,050
phenmedipham (Nor-Am)	Betanal	1.3 lb/gal EC	2,000
picloram (Dow)	Tordon 22K Tordon 10K Tordon beads (mixtures)	10 & 2% G 2 lb/gal EC	8,200
profluralin (CIBA-Geigy)	Tolban	4 lb/gal EC	2,200
prometon (CIBA-Geigy)	Pramitol	50% WP 25% EC	2,980
pronamide (Rohm & Hass)	Kerb	50% WP	5,620
propachlor (Monsanto)	Ramrod, Bexton	65% WP 20% G	710
propazine (CIBA-Geigy)	Milogard	50 & 80% WP	5,000
pyrazon (BASF)	Pyramin	80% WP	3,600
siduron (DuPont)	Tupersan	50% WP	7,500
silvex (Dow) (Amchem) (Thompson-Hayward)	Kuron Weedone 2,4,5-TP Ded-Weed Silvex	4 & 6 lb/gal EC	500-650
simazine (CIBA-Geigy)	Princep, Aqrazine	50, 80 & 85% WP 4,8 & 10% G	5,000
sodium arsenite	(several)	4,6,8 & 9.5 lb/gal WSL	10-50
sodium chlorate	(several)	4,19 & 28% L 99% powder	5,000
TCA (Dow)	Sodium TCA	90% WS pellets	5,000

Generic name[a] (producer)	Trade name[b]	Concentration and commercial formulation[c]	Acute oral LD_{50}[d]
tebuthiuron (Elanco)	Spike	50% WP	617-671
terbacil (DuPont)	Sinbar	80% WP	5,000
terbutryne (CIBA-Geigy)	Igran	50 & 80% WP	2,400
trifluralin (Elanco)	Treflan	4 lb/gal EC 5% G	3,700
vernolate (Stauffer)	Vernam	7 lb/gal EC 5 & 10% G	1,780
2,4-D (Dow)	(several)	(various L, G, WP)	300-1,000
2,4-DB (Amchem) (Rhodia)	Butyrac Butoxone	2 lb/gal EC	300-1,000
2,4,5-T (Dow)	(several)	(various L)	300
2,3,6-TBA (DuPont)	Benzac Trysben 200	2 lb/gal WSC	750
DPX 1108 (DuPont)	Krenite	4 lb/gal L	24,400

[a]Weed Science Society of America-approved name, or experimental number.
[b]"Several" indicates many trade names.
[c]EC means emulsifiable concentrate; G, granules; WSP, water-soluble powder; WP, wettable powder; WSC, water-soluble concentrate; WSS, water-soluble salt; WDL, water-dispersable liquid, L, liquid; WSL, water-soluble liquid.
[d]LD_{50}--milligrams of chemical per kilogram of body weight which is lethal to 50 percent of the test animals, usually white rats, when administered in a single, oral dose.

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Bioassay for Herbicide Residue

The two types of herbicides that cause the most concern over residue in agronomic crops are the triazines (atrazine and Princep) and the dinitroanilines (Treflan, Tolban, and Surflan). A triazine residue may cause injury to subsequent crops of soybeans, small grains, or legume seedlings; a dinitroaniline residue may cause injury to subsequent crops of small grains, sorghum, or corn. Chances of having a carryover are enhanced by cool, dry weather.

One way to determine carryover for yourself is to make a crop bioassay. A crop bioassay is performed by growing plants of crops in samples of the soil. If injury occurs on these test plants, then you can probably expect injury in the field. The closer to planting time the soil samples are taken and the test is made, the better indication you will have.

Soils samples. Sampling for a crop bioassay is similar to sampling for fertility testing. You should gather samples from several areas in the field. Field ends and knolls are often areas of expected high residue. You may want to run a separate test on samples from these areas. You will need about 1 gallon of soil per test.

Check soil. You should have some untreated (check) soil to use for comparing seedlings from treated and untreated soils. If you don't have a similar soil that has not been treated with the herbicide, you can make your own "untreated soil." Since activated charcoal mixed with soil will inactivate most herbicides, you can make a check by adding activated charcoal to a portion of the soil collected from the area in question. Capsules of activated charcoal can be purchased at most drugstores. Two capsules of the 0.5-gram size will be enough for 2 quarts of soil. The activated charcoal should be thoroughly mixed with the soil.

Mix Soil. If the soil samples are too high in clay, you can lessen crusting and improve seedling emergence by combining equal parts of coarse sand and soil. Mix these together thoroughly, then split the sample and add the charcoal to one portion to make the "check."

Potting soil. You should plant two or three pots each of the "treated" and the "check" soils, so that variability in growing the plants will not cause you to draw wrong conclusions. You can use pint or quart cans, cardboard containers, or greenhouse flats. Make sure there are holes in the bottom for drainage.

Planting seeds. Different levels of triazine herbicide residue can be determined by planting annual ryegrass or bluegrass, oats, and soybeans in the pots. The small-seeded grass is the most likely to show symptoms, and the soybeans are the least likely. Put the pots in a warm place where they will receive sunlight.

Different levels of dinitroaniline herbicide residue can be determined by planting annual ryegrass, sorghum or sudangrass, wheat, and corn. Here the annual ryegrass is the most likely to show symptoms, and the corn the least likely. Put the pots in a warm place.

Symptoms. Triazine symptoms will occur in 2 to 3 weeks. On oats, bluegrass, and ryegrass, the symptoms will show as leaf "burn" from the tip toward the leaf base. Soybean injury will appear as a browning or mottling of the unifoliate or first trifoliate leaves. Varying degrees of residues can be determined by which species are injured. Severe injury will result in complete kill of the seedlings.

Dintroaniline symptoms will be apparent about the time the seedlings are emerging. Symptoms include stunted plants, poor secondary root development, and leaves that fail to unroll properly. Varying degrees of residues can be determined by which species are injured. Severe injury may inhibit emergence altogether.

Minimize injury. If injury to the test plants is only slight, you can minimize potential injury in the field by a thorough mixing of the soil. This can be accomplished by plowing instead of disking or chisel plowing. Another way to minimize injury is to grow a less sensitive crop. You may have to plant the same crop as last year if severe injury symptoms appear.

Should triazine injury occur on oats but not soybeans, you may not want to use metribuzin (Sencor or Lexone) on soybeans because of the additive effect of triazine carryover and metribuzin activity on this crop.

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No. 1002

FUNGICIDES, DISINFECTANTS, GRAIN PRESERVATIVES, SURFACTANTS, AND SOIL-DISINFESTING CHEMICALS

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A fungicide is a chemical that kills or inhibits fungi. With sales of about $180 million in the United States each year, fungicides are widely used to protect plant seeds, foliage, flowers, fruits, and roots against disease-producing fungi. No single fungicide is suitable or effective against all fungi. Additional information can be found in *Seed Treatments for Field Crops* and Table 1, Soil-disinfesting Chemicals.

Fungicides are generally formulated as flowable liquids (F), emulsifiable concentrates (EC), dusts (D), granules (G), and most commonly as wettable powders (WP).

The concentration of a fungicide is expressed as a weight per unit volume or as a percent of the formulation. For example, a fifty percent wettable powder (50% WP) is half "active ingredient" (a.i.) and half inert ingredients consisting of emulsifying agent, carrier, surfactant, adjuvant, and other diluents. Liquid formulations generally indicate the number of pounds of active ingredient per gallon (lb. a.i./gal) on the label.

The actual amount of material to be applied depends on the concentration of the chemical (a.i.) in the preparation. A manufacturer may sell the same fungicide in a half dozen or more formulations where the percentage of a.i. may vary from 0.1 to 100 percent. *Be sure to read and follow the manufacturer's directions on the container label.* All formulations of a fungicide may not be registered for the same crops.

All plant disease-control chemicals should be stored in their original, closed, plainly labeled containers out of the reach of children, irresponsible adults, and animals. Avoid repeated or prolonged contact with the skin and inhalation of dusts, sprays, and vapors. Wash hands and face before eating or smoking. Do not contaminate streams, lakes, or ponds, or clean equipment near such water supplies.

Most fungicide spray programs are designed to protect against infection. This requires that the chemical uniformly and thoroughly cover all susceptible plant parts before penetration of the pathogen and infection occur. Rainy, foggy, or very humid weather favors the infection process of practically all fungal and bacterial pathogens. Whenever possible, spray programs should be altered to provide maximum protection during moist periods. Spray recommendations should provide acceptable control under conditions

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where about an inch of rain falls per week during periods of active growth. Extra sprays may be required during wet seasons, while fewer or no applications may be needed. in periods when the weather is unusually dry.

Fungicides are listed by coined (generic or common) names or representative trade (brand) names. Mention of a trade name or proprietary product is for convenience only. No endorsement or warranty of products is intended nor does it imply approval of a material to the exclusion of unnamed but comparable products that may be equally suitable.

Persons using plant disease-control products assume responsibility for their use in accordance with current label directions of the manufacturer. Always read the label carefully before using these chemicals. Pay special attention with respect to children and pets. Keep them out of the area when applying any material, and check the label for any special precautions relative to keeping people and animals out of the treated area for a period of time after application. Heed advice about protective clothing and steps to take in the event of chemical spills on your body or clothing. Dispose of empty containers according to label instructions. Plant disease-control chemicals are safe to use when handled and applied strictly according to instructions on the label.

Fungicides are often divided into three groups according to their action.

PROTECTIVE CONTACT FUNGICIDES are applied to seed, foliage, flowers, fruit, or soil as sprays, dusts, or granules to control disease-causing fungi before they can enter plants. These materials provide protection, but may NOT (a) kill fungi established inside a growing plant or seed (exceptions: powdery mildew and sooty mold fungi that are superficial and largely on the surface of plants can be killed by surface dusts or sprays after infection has occurred); (b) protect against pathogenic fungi entering through the roots such as root rots, wilts, and clubroot of crucifers; (c) control bacterial diseases, spiroplasmas, and mycoplasmas since most fungicides are poor bactericides; (d) protect against viruses; or (e) control nematodes.

Most fungicides in use today possess protective qualities. Those that are ONLY protective include zineb (Dithane Z-78, Black Leaf Sheen), thiram (Tersan 75, Arasan, Thylate), ferbam (Fermate, Karbam Black, Carbamate), ziram (Zerlate, Karbam White, Z-C Spray), sulfur, glyodin (Glyoxide), and possibly fixed or neutral copper compounds. These chemicals must be applied before an infection starts. They require frequent applications at 5- to 14-day intervals, depending on weather conditions. During rainy weather, sprays need to be applied at shorter intervals. Practically all dust and granule formulations function as protectants and should be used accordingly. Dusts should be applied when the air is calm and foliage is lightly covered with moisture. Early morning and evening are usually ideal times.

PROTECTIVE CONTACT-ERADICANT FUNGICIDES are applied in the same way as protective contact fungicides. However, they have another dimension of effectiveness, that of killing or inhibiting fungi after they have penetrated plants and become established. A commonly used term is "kickback," which means that an infection may be stopped after becoming established. For example, dodine (Cyprex) still provides some control if applied up to 36 hours after apple scab infection has occurred. Thus, it has a "kickback" for apple scab. In other words, dodine can prevent infection, and it also has good contact toxicity to fungus growth. "Contact toxicity" means that the compound may either kill or merely inhibit further growth. The list of protective contact-eradicant fungicides includes a large number of the most popular ones. Examples are cycloheximide (Acti-dione), benomyl (Benlate, Tersan 1991), captan (Orthocide) captafol (Difolatan), dodine, dinitro materials (Elgetol), dinocap (Karathane), folpet (Phaltan), lime-sulfur, maneb (Dithane M-22, Manzate), mancozeb or maneb plus zinc ion (Manzate 200, Dithane M-45, Fore), thiabendazole or TBZ (Mertect), thiophanate compounds (Topsin-M, Spot Kleen, Zyban, Cleary's 3336), Dikar, Niacide M, nabam, Amobam, Polyram, Botran, and such seed treatments as formaldehyde and hot water. Some of these also have good residual and systemic properties.

SYSTEMIC FUNGICIDES, OR CHEMOTHERAPEUTANTS, are chemicals that are absorbed and distributed within the plant to control a disease for several weeks or months. Only a few chemicals now available act in this way. Examples are cycloheximide, benomyl, MBC-phosphate (carbendazim), thiabendazole, thiophanate compounds, chlornoeb (Demosan, Tersan SP), carboxin (Vitavax), oxycarboxin (Plantvax), and 8-hydroxyquinoline materials. To be effective, a systemic fungicide must be taken up by the seed, foliage, roots, or stem(s) of the plant and be translocated in an active state to where infection occurs.

Streptomycin, an "antibiotic" bactericide, is topically systemic when applied to foliage. This means that streptomycin can be absorbed by leaf tissue to inhibit bacterial infection, but does not move systemically from leaf to leaf.

Commonly Used Fungicides

Many new fungicides have been introduced into American agriculture since 1950. These chemicals have largely replaced old standbys such as bordeaux mixture; fixed or neutral coppers; dinitro materials; lime-sulfur; and wettable, dust, or paste sulfurs. The older materials are messy to handle and corrosive to spray equipment. They also cause injury to plants under cold, hot, or slow-drying conditions, and may often reduce the quality and quantity of the crops they were designed to protect. Unfortunately, some retail outlets still stock outmoded fungicides and carry only a few of the safer and more effective fungicides—captan, zineb, maneb, mancozeb, dodine, folpet, thiram, chlorothalonil (Daconil 2787, Bravo), benomyl, and other products listed below.

Fungicides are marketed under a bewildering assortment of trade names. To help relieve confusion, a set of common (generic) or "coined" names has been officially adopted and is now widely used on package labels in place of, or with, the more complicated chemical names.

The following list and the paragraphs immediately below it summarize the common names, active ingredients, trade names, and principal uses of the more commonly used fungicides.

Fungicides that have no common (generic) name, i.e. have a trade name that does not include a common name, or are not widely used at present to treat seed, foliage, flowers, fruit, or soil, are listed alphabetically in Fungicides of Less General Use.

This listing is incomplete since there are about 35,000 disease-control products now registered by the Pesticides Registration Division of the Environmental Protection Agency (EPA) in Washington, D.C. and many additions, deletions, and other changes are made monthly. Some of the products listed may no longer be manufactured, but may still be available in certain retail outlets or directly from the manufacturer. Should you need more detailed information (manufacturers, sources), or information on plant disease-control products not listed, please contact your state extension plant pathologist.

The effectiveness of fungicides on foliage, seed, and in soil is determined by timing, dosage, where and how applied, weather, type of tillage system, how well the treatment is matched to the disease problem and soil situation, and other factors. Proper consideration of all these factors is essential for maximum benefits from these chemicals.

Most of the chemicals listed are "pure" compounds; only a relatively few contain mixtures of more than one fungicide or fumigant. Little attempt has been made to include the thousands of "multipurpose" pesticides that include mixtures of insecticides, miticides, and fungicides.

COMMONLY USED FUNGICIDES AND THEIR PRINCIPAL USES

ANILAZINE [4,6-dichloro-N-(2-chlorophenyl)-1,3,5-triazine-2-amine]

A broad-spectrum, protective foliar fungicide useful in controlling many turfgrass diseases plus some anthracnoses, Botrytis blights, fungus leaf spots, and blights of many vegetables, woody ornamentals, flowers, bush and bramble fruits, and strawberries. *Trade names.* Dyrene 50% Wettable Powder Foliage Fungicide; Agway Granular Turf Fungicide With Dyrene; Patterson's Turf Fungicide W/Dyrene; Dyrene Lawn Disease Control; Scotts ProTurf Fungicide III; Dymec 50 Turf Fungicide; Dyrene Turf Fungicide.

BENOMYL [Methyl 1-(butylcarbamoyl)-2-benzimidazolecarbamate]

A very low toxicity, broad-spectrum fungicide that is preventive, curative, long lasting, and systemic. Benomyl is effective at very low dosages against a wide range of fungus leaf spots, blotches and blights; fruit spots and rots; sooty molds; scabs; bulb, corm and tuber decays; blossom blights; powdery mildews; Botrytis blights; Verticillium and Fusarium wilts of annuals; anthracnoses; certain rusts; common soil-borne crown and root rots; clubroot of crucifers, and a number of turf diseases. Benomyl also prevents certain fungi, (e.g., the apple scab fungus) from sporulating. Because exclusive use of benomyl has frequently led to the development of tolerant strains of fungi, another fungicide is added to benomyl.
Trade names. DuPont "Benlate" Benomyl Fungicide; Tersan 1991 Turf Fungicide; Bonide Benomyl (DuPont New Systemic Fungicide); Science Benomyl Systemic Fungicide; Rockland Benomyl Fungicide; Benomyl Turf Fungicide Granules; Miller's Benomyl Systemic Fungicide, Patterson's Benomyl Systemic Fungicide; Scotts ProTurf fertilizer plus DSB Fungicide. *MBC-phosphate (carbendazim) products* for injection treatment as an aid in control of Dutch elm disease (formerly Lignasan BLP) include Hopkins Correx Fungicide, Agway Elmosan, Pratt Elm Tree Noculate, Arboral Fungicide, and Lily/Miller Ulmasan. All contain 0.7% methyl 2-benzimidazolecarbamate phosphate, a close relative of benomyl. These products are *only* to be used by trained arborists and others trained in injection techniques.

BORDEAUX MIXTURE

A broad-spectrum, long-lasting, protective fungicide now used mostly as a soil drench, dormant spray, and foliar spray to control needle diseases of conifers. It may "scorch" foliage and russet fruit of some plants, e.g., many flowers, hollies, and maples in cold, damp weather. Injury is worse on plants weakened by disease, insect, or mite injury. Bordeaux is most effective when freshly mixed. It is also used as an insect repellent and as a general disinfectant for work surfaces, storage cellars, and other areas. *Trade names.* Prepared dry bordeaux products include Acme Bordeaux Mixture; Patterson's Bordeaux Mixture; Copper Hydro Bordo; Bor-dox; Pratt Bordeaux Mix; Black Leaf Bordeaux Powder; Ortho Bordo Mixture. [Bordeaux is a mixture in water of copper sulfate crystals (bluestone or blue vitriol) or powder ("snow") and hydrated spray lime. The formula is written in figures (e.g., 8-8-100). The first figure is copper sulfate in pounds, the second is spray lime in pounds, and the last number is water in gallons.]

BOTRAN (DCNA) [2,6-dichloro-4-nitroaniline]

A foliar, seed, soil, and post-harvest fungicide that controls a range of seed decays and seedling blights; stem (crown), fruit, bulb or corm rots; and blights of certain vegetables, tree and bush fruits, and ornamentals caused by species of *Botrytis, Monilinia, Rhizopus, Sclerotinia,* and *Sclerotium.* Also effective as a cut-flower spray or dip for Botrytis control. Botran may injure some tender crops.
Trade names. Botran 50% WP, Botran 75W, Botran 75 WP, E-Z-Flo Botran 6 Dust. Bo-Cap and Botec Peanut Seed Protectant are 30:30 mixtures of Botran and captan, while Orthocide Botran 35-35 Seed Protectant contains 35% each of Botran and captan. Ortho Difolatan Botran 20-60 Seed Protectant and 35-35 Seed Protectant contain 20%-60% and 35% each of Botran and captafol, respectively.

CAPTAFOL [N-[(1,1,2,2-tetrachloroethyl) thio]-4 cyclohexene-1,2-dicarboximide]

A very long-lasting, protective foliar, fruit, seed, and soil fungicide related to captan and folpet. Controls downy mildews, numerous fungus leaf spots and blights, blossom blights, fruit spots and rots, scabs, anthracnoses, seed rot, damping-off, and gray-molds *(Botrytis)* of fruits, vegetables, and ornamentals. Some persons are allergic or become sensitized to captafol. Avoid contact with eyes, skin, or clothing.
Trade names. Ortho Difolatan 4 Flowable; Ortho Difolatan 4 Flowable Seed Protectant.

CAPTAN [N-[(trichloromethyl)thio]-4-cyclohexene-1,2-dicarboximide]

Excellent, low toxicity, broad-spectrum, moderately residual fungicide to control a wide range of leaf and blossom blights, leaf and fruit spots, blotches, anthracnoses, sooty molds, flyspecks, certain downy mildews, scabs, fruit rots, leaf curls and galls on bush and tree fruits, flowers, trees, shrubs, and turf. Seed, corm, tuber, and bulb protectant (often mixed with insecticide) for vegetables, ornamentals, cereals, and grasses. Pre-harvest packing box treatment and post-harvest dip, spray, or wash for many fruits and vegetables. Does NOT control powdery mildews and rusts. Applied as a dust or drench to soil in plant beds to control crown rot, damping-off and seedling blights—often in combination with PCNB. Widely used in multipurpose sprays and dusts, especially for fruits and flowers. Available primarily as wettable spray powders and dusts. Both a protectant and a mild eradicant. Captan is more effective against *Botrytis* under low temperatures (48°-50° F) than some other fungicides.
Trade names. Stauffer Captan 50-WP, 80-WP, Captan-Moly-Planterbox Treater, Captan-Thiram 43-43 WP & Dust; Captan 25, 75, and 80 Seed Protectant; Captan Garden Spray; Evershield Captan Seed Protectant; Gallotox Captan FP-700R; Captan 80 Spray-Dip; Orthocide 50 and 80 Wettable; Orthocide Fruit and Vegetable Wash; Agway Captan 5D and 7.5D; Orthocide 65 and 75 Seed Protectant; Miller's Captan 50W; Patterson's Captan Garden Spray; F & B Captan 7.5 Dust and Captan 50-WP; Chipman Captan Dust; Hopkins 7-1/2% Captan Dust; Orthocide 5 Dust, 7.5 Dust, 10 Dust, 15 Dust, and 80 Concentrate; Occidental Captan; Security Captan; Miller's Captan Dust and Captan Garden Dust; Bonide Captan 50W; E-Z-Flo Captan 7-1/2 Dust; Captan 25 Planterbox Treater; Hopkins 25% Captan Seed Protectant and Captan-Moly Planter Box Seed Protectant; Farmrite Captan 5% and 10% Dust; Green Cross 7.5% Captan Dust; Ortho Soybean Seed Protectant and (MO); Orthocide Potato Seed Treater; Orthocide 90 and 92 Seed Protectant Concentrate; Orthocide 4 Flowable Seed Protectant; Security 7-1/2% Captan Peach Dust; Naco Captan 7.5 Dust; Chevron 90 Concentrate; Vancide 89.

CARBOXIN [5,6-dihydro-2-methyl-1,4-oxathiin-3-carboxanilide]

A protective contact-systemic fungicide effective against various seed- and soil-borne smuts (including loose smut of wheat and barley), some seed-rotting and seedling blight fungi, some rusts, common scab of potato, Rhizoctonia damp-off of seedlings, and Verticillium wilt of annuals. Applied to seeds or soil at planting time.

Trade names. Vitavax Fungicide; Vitavax-25 DB Fungicide; Vitavax-EVS Concentrate; Vitavax Flowable Fungicide; Vitavax-17 Flowable Fungicide; Evershield V Seed Protectant.

Vitavax-200 Fungicide contains 37.5% carboxin and 37.5% thiram, while Vitavax 200 Flowable Fungicide contains 17% each of carboxin and thiram.

CHLORONEB [1,4-dichloro-2,5-dimethoxybenzene]

A protective, locally systemic seed and soil fungicide that controls pre- and post-emergence damping-off (seedling blights), and root rots of vegetables, soybeans, and ornamentals, as well as Fusarium patch, Pythium and Typhula blights of turfgrasses.
Trade names. Demosan 65W Chloroneb Fungicide; ProTurf Fungicide II; Tersan SP Turf Fungicide, etc.

Demosan T Seed Fungicide contains 40% chloroneb and 22.5% thiram.

CHLOROTHALONIL [2,4,5,6-tetrachloroisophthalonitrile]

Excellent, very low toxicity, broad-spectrum, protectant fungicide to control many fungus leaf spots and blights, blossom blights, scabs, anthracnoses, fruit spots and rots, gray-molds *(Botrytis)*, certain rusts, powdery and downy mildews of turfgrasses, flowers, trees, shrubs, vegetables, and certain fruits. Gives poor control of soil-borne fungi because of rapid breakdown. Use cautiously; some cases of dermatis reported with all formulations.
Trade names. Daconil 2787; Daconil 2787 Flowable Fungicide; Bravo W-75; Bravo 6F; Exotherm Termil; Diamond 75% Chlorothalonil, Scotts ProTurf 101V broad spectrum fungicide and ProTurf fertilizer plus 101 broad spectrum fungicide. Exotherm Termil is a special formulation (20% chlorothalonil) for use in closed greenhouses to control *Botrytis* and other foliar and flower blights of ornamentals and tomatoes. One can treats 1,000 square feet of greenhouse area.

COPPER (Fixed or Neutral) COMPOUNDS

Low toxicity, moderately residual, broad-spectrum fungicides that have largely replaced bordeaux mixture and are available for use as sprays, dusts, and soil drenches. Useful for controlling a wide range of fungus leaf and fruit spots; blotches and blights; downy mildews; powdery mildews; rots; scabs; anthracnoses; and some bacterial diseases including bacterials blights of beans, pepper, tomato, lilac, and walnut. Fixed coppers are usually finely divided, relatively insoluble powders generally much more compatible with other pesticides than bordeaux, easier to mix and handle, and less corrosive to spray equipment and less toxic to tender foliage in cool, cloudy, damp weather. Spray materials usually contain 20 to 55 percent metallic copper, dusts 3 to 35 percent.

Copper fungicides are also used as algacides and wood preservatives.

Federal agencies have decided that no tolerance levels need to be established for most copper compounds.
Trade names. These materials can be conveniently divided into five categories:
1. *Sulfates*--Basic Copper Sulfate, Kobasic, Ortho Copper 53 Fungicide, Basi-Cop, Microcop, Citco Tri-Basic Copper Sulfate, Naco 53% Basic Copper Sulfate, Copper '7' Dust, Spraycop 530, T-B-C-S 53, Neutro Cop 53, Copper 53 Fungicide. Cop-O-Zinc contains copper sulfate plus zinc salt.
2. *Chlorides*--Coprantol, Aceto Copper Chloride, Copper Oxychloride, C-O-C-S, Kaurital.
3. *Oxides*--Kuprite, Cuprocide, Kocide 101 Wettable Powder and 404 Flowable, Copper Oxide, Cuprous Oxide, Brown Copper Oxide, Yellow Cuprocide.
4. *Liquids*, i.e., emulsifiable--Oxy-Cop 8L, Copoloid, Cop-O-Cide, Citcop 4E, Copper-Count, Copper-Count-N, Mildew King, Sol-u-Cop, Carmel Formula GH-41 & Greenhouse Fogging.

5. *Miscellaneous*--Copper Oleate, GH-41 Copper Resinate, Copper Carbonate, Tri-Cop, Zinc Coposil Fungicide, Copper Zeolite.

Oxy-Cop 8LS, Copper-Count-S and -NS are liquid fungicides containing 8% ammonical copper and 5% sulfur.

CYCLOHEXIMIDE [3-[2-(3,5-dimethyl-2-oxocyclohexyl)-2-hydroxyethyl]-glutarimide]

A short residual, eradicant, highly toxic, anti-fungal antibiotic that is absorbed through plant surfaces and is distributed locally within a plant. Effective against powdery mildews, certain rusts, a number of turfgrass diseases, cherry leaf spot, and azalea petal blight. Various formulations are sold for different purposes. Acti-spray is a tablet that dissolves in water. Cycloheximide is used at concentrations as low as 1 part in a million parts of water. Plants are very sensitive to overdose with this chemical. Do *not* apply at temperatures above 85° F.
Trade names. Acti-dione PM, Acti-dione WP (Flower Fungicide), Acti-dione WP (Lawn & Turf Fungicide), Acti-dione TGF, Acti-dione TGP, Actispray.

Cycloheximide-thiram is sold as Acti-dione Thiram Lawn Fungicide and Acti-dione Thiram Powder.

Cycloheximide-PCNB is sold as Acti-dione RZ.

DINOCAP [2-1(1-methylheptyl)-4,6-dinitrophenyl crotonate and isomers]

A short residual but good eradicant fungicide specific against powdery mildews of fruits, vegetables, ornamentals, and turfgrasses. Also suppresses certain mites. Has replaced sulfur in some multipurpose sprays and dusts. Do *not* use in hot weather (above 85° F) as dinocap may be phytotoxic. Use a wetting agent with dinocap to ensure wetting the mildew growth.
Trade names. Karathane WD, Karathane Liquid Concentrate, Miller's Karathane 2D and Garden Karaspray.

Dikar is a broad-spectrum fungicide-miticide containing 4.7% dinocap and 72% mancozeb (Dithane M-45) used primarily by commercial apple growers.

Orthocide Karathane 50-6 Wettable contains 50% captan and 4.87% dinocap. It is used on fruits, ornamentals, and vegetables.

DODINE [N-dodecylguanidine acetate]

Controls certain foliar diseases (fungus leaf spots and blotches, scabs and anthracnoses) of various fruit and nut crops, roses, and shade trees. Gives long-lasting protection; a good eradicant. Does NOT control powdery mildews and rusts. May be sold combined with Crag Glyodin.
Trade names. Cyprex 65-W Fruit Fungicide; Agway Dodine 1D; Miller's Cyprex 4D; Naco Dodine 2, 3, 4, and 6 Dusts; Cyprex Dodine Dust; E-Z-Flo Cyprex 4 Dust; Hopkins 2% and 4% Dodine Dust.

ETRIDIAZOL [5-ethoxy-3-(trichloromethyl)-1,2,4-thiadiazole]

A low toxicity, moderately residual soil, turf and seed fungicide specific for controlling soil-borne water molds *(Aphanomyces, Phytophthora, Pythium)* that cause crown and root rots of many ornamentals and Pythium blight of turfgrasses. Etridiazol is often sold in combination with PCNB to give broad-spectrum control of seed decay, damping-off (seedling blights), and crown, stem, and root rots of many field crops, vegetables, flowers, nursery crops, and other ornamentals.
Trade names. Olin Terrazole Technical and Terrazole 35% Wettable Powder, Koban, Truban.

Extridiazol-PCNB mixtures include Olin Terraclor Super-X (Emulsifiable, Granular, with Di-Syston Systemic Insecticide, with Thimet Systemic Insecticide, 20-5 Dust with

Graphite, with Moly, with Graphite) and Terra-Coat (L-21, L-205, SD-205) Seed Treatment Fungicides. *Banrot* is a combination of etridiazol (Truban 15%) and thiophanate-methyl (Topsin-M 25%).

FERBAM [Ferric dimethyldithiocarbamate]

A general-purpose, very low toxicity, long-lasting fungicide that controls a wide range of foliar diseases of flowers, trees, shrubs, and fruit, including fungus leaf spots and blotches, scabs, and rusts. Ferbam is sometimes applied as a soil drench to control damping-off and seedling blights. Is often used in multipurpose sprays. May leave an objectionable black deposit on flowers, woodwork, and other surfaces. Mostly protective in action. Controls rusts but NOT powdery mildews. Ferbam is now rather difficult to find in many garden supply stores.
Trade names. Fermate Ferbam Fungicide; Karbam Black; Carbamate; Stauffer Ferbam 76-W; Agway Ferbam 76W and 7.6D; E-Z-Flo Ferbam 76; Ortho Ferbam 76; Allied Ferbam; Aceto Ferbam 76% and 93%; Kerr-McGee Ferbam; Olin Ferbam; Thompson-Hayward Ferbam; Grace Ferbam; Chemform Ferbam (Wettable Powder); Ferbam 76W; Ferbam 95W; Miller's Ferbam; Naco Hi-Test Ferbam Wettable Powder; Vancide FE 95-W and FE Flowable; Champion 15% Fermate Dust; Sup'r-Flo Ferbam Flowable; Crown 15% Fermate Dust; Gold Kist Fermate Dust; Green Cross 7% Karbam Black Dust Fungicide and 76% Karbam Black Fungicide; Naco Fermate 15 Dust; Bartlett Ferbam 76W; Farmrite Ferbam 76%; Chempar Ferbam 76 Wettable Powder; Patterson's Ferbam; Security Ferbam Fungicide; Shepard Chemical Ferbam.

FENAMINOSULF [p-Dimethylaminobenzenediazo sodium sulfonate]

Very persistent soil, seed, and turfgrass chemical that is fungistatic to many fungi. It controls seed decay, cutting rots, damping-off, and stem and root rots of many ornamentals, vegetables, fruits, and turfgrasses caused by water molds *(Aphanomyces, Phytophthora, Pythium)*. It is often mixed with anilazine (Dyrene) or PCNB (Terraclor). Fenaminosulf may be applied as a soil spray or drench, or blended into a dry soil mix. Apply immediately after mixing, since exposure to light results in a rapid loss of fungicide activity. Do *not* apply to plants being propagated from cuttings until the root systems are established.
Trade names. Dexon 35% Wettable Powder Turf and Soil Fungicide; Dexon 70% Wettable Powder Seed and Soil Fungicide; Dexon 70 Seed Protectant.

Patterson's Root and Crown Rot Control and Dexon-Terraclor 35-35 Wettable Powder are mixtures of Dexon and PCNB.

Dexon D contains 32% and 40% chlorothalonil.

FOLPET [N-[(trichloromethyl)thio]phthalimide]

Related to captan and captafol, and used to control many of the same diseases--fungus, leaf and fruit spots, rots, scabs, blights, anthracnoses, downy mildews, sooty molds and fly specks, and leaf curls and galls--on bush and tree fruits, flowers, vegetables, trees, and shrubs. A protectant-eradicant fungicide that gives fair control of many powdery mildews but not of rusts.
Trade names. Ortho Phaltan Rose & Garden Fungicide; Ortho Phaltan 50 Wettable; Niagara Phaltan 50 Wettable; Stauffer Folpet 50-WP; Agway Folpet 50-W; Miller's Phaltan 50-W; Bonide Folpet 50W; "Fungitrol;" Farmrite Phaltan 50-W; Naco Phaltan Folpet 50 Wettable Fungicide; Acme Phaltan Fungicide; Science Rose and Garden Fungicide; Aceto Folpet; Chevron Folpet Wettable; Patterson's Phaltan Wettable Powder.

MANCOZEB (or MANEB AND ZINC ION) [Includes products containing zinc and maneb]

Excellent, very low toxicity, broad-spectrum, largely protectant fungicide for controlling fungus leaf spots, blights and blotches, scabs, rusts, rots, and anthracnoses

of cereals, nuts, fruits, turfgrasses, vegetables, trees, flowers, and shrubs. This material has a spectrum of activity very similar to maneb and zineb (both below). However, it is more effective. Does NOT control powdery mildews.
Trade names. Manzate 200 Fungicide; Tersan LSR Turf Fungicide; Dithane M-45; Fore; Acme Fore; Vancide Maneb Flowable; Amazin Zinc Enriched Maneb 80 Fungicide; Science Fore Lawn Fungicide; Pratt Lawn & Garden Fungicide and Liquid Maneb; Naco Potato Seed Piece Fungicide Dust; Farmrite Potato Seed Dust; E-Z-Flo Dithane M-45 Potato Seed Piece Fungicide; Hopkins Potato Seed-Piece Fungicide Dust; Security 6% Dithane M-45; Agsco Blitex Dust DM-6; Sup'-r-Flo Maneb Flowable, Formec 80 Turf & Ornamental Fungicide.

MANEB [Manganese ethylenebisdithiocarbamate]

Excellent, general, broad-spectrum, very low toxicity fungicide used to control a wide range of foliar and fruit diseases of trees, shrubs, turfgrasses, flowers, vegetables, and some fruit and nut crops. Very useful for tomatoes, potatoes, carrots, beans, onions, vine crops, roses, chrysanthemums, and sugar beets. Used in many multi-purpose mixes for vegetables, tomatoes, potatoes, flowers, and roses. Controls rusts but NOT powdery mildews. Both a protectant and an eradicant. Has the same uses as mancozeb and zineb.
Trade names. Manzate Maneb Fungicide; Manzate D Maneb Fungicide; Dithane M-22 and Dithane M-22 Special with Zinc; Sears Lawn Fungicide; Aceto Amazin Maneb 80 WP and Maneb 80 and Maneb Flowable; Patterson's Maneb Fungicide; E-Z-Flo Maneb 7 Dust; Shepard Chemical Maneb 80% WP; Pennwalt Maneb 80; Agsco Blitex 80 M; Dust M-6, DB Yellow and DB Green; Chevron Maneb; Black Leaf Maneb Fungicide; Agrisect Brand Maneb (Wettable Powders and Dusts); Agway Maneb 4.5D; Champion 2% Maneb Dust; Miller's Dithane M22-6D and Dithane Dust; Twin Light Maneb Dust; Ortho Maneb 80 Fungicide; Science Maneb Garden Fungicide; Naco Maneb 80 Fungicide; BASF Maneb 80WP; Security Maneb Dust; Agrox N-M Drill box Non Mercurial.

PCNB [Pentachloronitrobenzene]

A very long-lasting soil, turf, seed, bulb, and corm fungicide available as wettable powders, dusts, granules, and emulsifiable concentrates that controls various soil-borne root, bulb, corm, stem, and crown rots of vegetables, flowers and other ornamentals, clubroot of crucifers, potato scab and scurf, pink rot of celery, camellia and azalea flower (petal) blights, brown patch of turfgrasses, and damping-off (seedling blights) of many plants. PCNB is often mixed with etridiazol (see under Etridiazol), captan, ferbam, thiram, fenaminosulf (Dexon), mancozeb, Polyram, or folpet, and incorporated into soil before planting as a dust or drenching spray in the seedbed.
Trade names. Terraclor 10% Dust, 20% Dust, 40% Dust, 80% Dust Concentrate, 10% Granular, Emulsifiable, and 75% Wettable Powder; Tri-PCNB; Pearson's Green Lawn Fungicide; Fungi-clor; Turfcide 10% Granular Fungicide and Emulsifiable Fungicide; Aceto PCNB 80% and 100%; Scotts Lawn Disease Preventer, Turf Builder Plus Lawn Disease Preventer, and ProTurf New FFII; Ortho Lawn Fungicide; Terra-Coat LT-2 and 2-LF Seed Treatment Fungicide; Naco Terraclor Dust; Terraclor 2 EC and Granules.

Captan-PCNB mixtures are sold as Orthocide Soil Treater "X" and "3X"; Orthocide PCNB 10-20 Dust; Orthocide PCNB-Nutrient Spray; Terracap; Stauffer Captan-Terraclor 10-10 Seed Treatment and 30-30 Seed Protectant; Terraclor 20-Captan 10 Dust; Terraclor 50-Captan 25 Wettable Powder, PCNB-Captan 25-25 Wettable Powder.

POLYRAM or METIRAM [Zinc polyethylenethiuram disulfide complex or polyethylene polymer]

A very low toxicity, broad-spectrum, largely protectant fungicide for application on foliage, fruit, seed, and soil. Controls rusts, scabs, sooty molds, downy mildews,

a wide range of fungus leaf spots and rots, and Botrytis blights of certain vegetables, tree fruits and nuts, roses, and other ornamentals. Polyram's range of activity is very similar to mancozeb, maneb, and zineb.
Trade names. Polyram Wettable Powder; Niagara Polyram 80 WP, 7 Dust, and Seed Treater; Security Polyram; Farmrite Potato Seed Piece Treater; Gold Kist 5% Polyram Dust; Agway Polyram 7D and Polyram 80W, Naco Polyram 3.5 Dust and Polyram Dust; Polyram 80 Wettable Powder; Polyram 7 and 10 Dust; Polyram Seed Treater; Hopkins Potato Seed Treater-P Fungicide; Niagara Polyram Potato Seed Treater.

Polyram-PCNB is sold as a 10:10 dust.

STREPTOMYCIN [Streptomycin sulfate or nitrate]

A short residual, antibacterial antibiotic used to control fire blight of pome fruits and ornamentals, walnut blight, bacterial spots of pepper, tomato and foliage plants, bacterial wilts, blights and rots of various trees and ornamentals, and blackleg (soft rot) of potato. May cause injury to some plants. Apply only under slow-drying conditions (such as during the night) and before infections occur. Do *not* use at low temperatures, which impair its effectiveness. Streptomycin should be used alone unless it has been purchased in prepared mixes.
Trade names. Agrimycin 17; Stauffer Streptomycin; Phytomycin; Ortho Streptomycin Spray; Streptomycin Antibiotic Spray Powder; Streptomycin Wettable Powder; Ag-Strep; Agri-Strep.

Agri-mycin 100 and 500 also contain the antibiotic oxytetracycline (Terramycin).

Captan-Streptomycin 7.5-.01 Potato Seed Piece Protectant contains 7.5% captan and 0.01% streptomycin.

Agrox Strep, a planterbox seed treatment for corn, contains 5% streptomycin, 20% captan, and 21.5% diazinon.

Hopkins Bean Seed Protectant contains 25% each captan and diazinon, and 6.25% streptomycin sulfate.

SULFUR COMPOUNDS (including Liquid Lime-Sulfur)

Old-time combination fungicide-insecticide-miticide that is only protective. It controls powdery mildews, rusts, and many fungus leaf spots, blights, scabs, and fruit rots. May injure plants in hot (85° F or above), dry weather. In dust form the particles should be fine enough to pass through a 325-mesh screen.

Lime-sulfur is a combination fungicide-insecticide (scalecide) more phytotoxic than other sulfurs. It is caustic and disagreeable to apply, and will discolor paint. Now almost exclusively used as a dormant or delayed dormant spray for bramble and tree fruits, roses, and other woody plants. A reddish-brown, vile-smelling liquid, it is made by boiling hydrated lime and sulfur together. It should not be exposed to freezing. Like bordeaux, it is not compatible with many modern pesticides.
Trade names. Sulfur; Magnetic "70" and "95;" Ortho Flotox Garden Sulfur; Sulfuron; Microfine Sulfur; Corosul S; Kolodust; Kolospray; Bonsul Spray-Dust Sulphur; Naco Micronized Wettable Sulfur; Pratt Wettable Sulfur; Sperlox-S.

Kolofog contains 30% fused bentonite sulfur. Fungi-Sperse, Liquid Sulfur, and Sperlox are liquid sulfurs. Micro-Sperse contains 54% sulfur and 3% copper.

Lime-sulfur is sold as Acme Lime Sulfur Spray, Miller Lime Sulfur Solution, F & B Lime Sulphur Solution, Orthorix Spray, Security Lime Sulfur.

THIABENDAZOLE or TBZ [2-(4-Thiazolyl)benzimidazole]

A very low toxicity, broad-spectrum, preventive-curative-systemic fungicide chemically related to benomyl. Useful as a foliar, fruit, bulb, corm, tuber, seed, and soil fungicide, and for thermal fumigation.

Trade names. Mertect 40, 140F, 160, 260, 340F, and 360; Tecto; Thiabendazole; TBZ.
Arbotect 20-S, the phosphate salt of TBZ, is registered for controlling Dutch elm disease.

THIOPHANATE MATERIALS [Dimethyl or diethyl [(1,2-phenylene) bis(iminocarbonothioyl)] bis carbamate]

Very low toxicity, broad-spectrum, preventive-curative-systemic fungicides closely related to benomyl and used to control a variety of the same diseases.
Zyban and Banrot control a wide range of soil-borne fungi of bedding, foliage, and container-grown plants when used as foliar sprays, soil drenches, or incorporated as dusts or powders into soil mixes.
Trade names. Topsin-M 70W and E; Fungo 50; Chipco Spot Kleen Turf Fungicide; Zyban; Cleary's 3336; Topmec 70W Turf Fungicide; Scotts ProTurf systemic fungicide.
Banrot is a combination of etridiazol (Truban 15%) and thiophanate-methyl (Topsin-M 25%).

THIRAM [Tetramethylthiuram disulfide]

A broad-spectrum, protective seed, bulb, corm, and tuber fungicide for field crops, vegetables, flowers, grasses, and certain tree and bush fruits. Thiram is available as dusts, liquids, pastes, and most commonly as wettable powders. It controls many foliar and fruit diseases (leaf spots and blotches, scabs, rots) of turfgrasses, vegetables, trees, shrubs, flowers, and fruits. Controls rusts but NOT powdery mildews. Applied to soil as a dust or drench to control crown rot, damping-off, and seedling blights. Do *not* apply to produce intended for canning or deep freezing as it may "taint" the produce. Arasan 42-S Thiram Fungicide and Repellent is also sold as a deer, rabbit, bird, and rodent repellent for protecting fruit trees, shrubs, nursery stock, and other ornamentals.
Trade names. Tersan 75 Thiram Turf Fungicide; Thylate Thiram Fungicide; Arasan 50-Red Thiram Seed Protectant, 42-S Thiram Fungicide and Repellent, 70-S Seed Protectant, and 75 Thiram Seed Protectant; Evershield T Seed Protectant; Agway Thiram 4.8D and Tinasad; E-Z-Flo 5% Thylate Dust; Rhodia Sup'r-Wet Thiram; Farmrite Thiram "95" and 5% Dust; Doggett Fison Turftox; Metasol Thiram 75%; Robeco Thiram 98/100%; Shepard Chemical Thiram; Occidental Thiram; Fungisan; Roberts Thiram; Chipco Thiram 75; Naco Hi-Test Thiram Wettable Powder; Thiuram 75; Spotrete; Thiramad Turf Fungicide; Niagara Thiram 65 Wettable Powder; Aceto Thiram-75; Thiram 65% and Thiram-100; Miller's Thiram 65 and 75W; Vancide TM-95 and TM Flowable; Chemform 75% Thiram WP; Kerr-McGee Thiram; Science Gladiolus and Bulb Dust.

ZINEB [Zinc ethylenebis (dithiocarbamate)]

Excellent, very low toxicity, general, broad-spectrum fungicide for tree and bush fruits, vegetables, flowers, trees, shrubs, and nuts. Controls wide range of leaf and blossom spots, blotches, or blights, fruit spots and scabs, Botrytis blights, downy mildews, leaf curls and galls, sooty molds and fly specks, anthracnoses, rusts, black knot of stone fruits, certain turfgrass diseases, damping-off (seedling blights), and cutting rots. Will NOT control powdery mildews. Used in many multipurpose sprays and dusts for vegetables and flowers. Only protective in activity. Zineb is now becoming difficult to find in many garden supply stores.
Trade names. Dithane Z-78; Security Zineb Dust; Science Zineb Fungicide; Ortho Zineb Wettable; Black Leaf Sheen; Aceto Zineb-75 and 85%; Acme Zineb 75W Fungicide; Niagara Zineb 75 Wettable; Vancide Zineb 85% WP; Sherwin-Williams Zineb; E-Z-Flo Zineb 75; Pennwalt Zineb W-75; Miller's Zineb 6D; Stauffer Zineb 65-W and 75-W; Ortho Zineb 5 Dust; Chipman Zineb; Patterson's Zineb Wettable Powder; Chemform 65% Zineb; Chempar

Zineb 75 WP; Zineb Garden Fungicide; Shepard Chemical Zineb; Agrisect Brand Zineb 75% Wettable Powder; Hopkins 15% Zineb Dust and 6% Dithane Z-78 Dust; Naco Dithane 6 and 10 Dust; D.H. 10% Dithane Dust; Gold Kist Zineb Dust No. 10; Green Cross Thiogreen Dust Fungicide; New Dragon Tomato Dust; Miller Zineb 75%; Staples Dithane Seed Treating Dust; Vancide Zineb 85; BASF Zineb 80WP; E-Z-Flo Special Mushroom Dust; Superior's Zineb 75% Wettable.

ZIRAM [Zinc dimethyl dithiocarbamate]

General, very low toxicity fungicide, strictly protective. Useful for certain fungus leaf spots and blights of vegetables, fruits, nuts, and ornamentals; especially good for tender seedlings. Applied as spray, dust, or soil drench. Used in some multipurpose mixes. Does NOT control rusts or powdery mildews. Ziram is now difficult to find in garden supply stores.
Trade names. Zerlate Ziram Fungicide; Karbam White; Ziram Spray Fungicide; Niagara Z-C Spray; Aceto Ziram-75 and -100; Allied Ziram; E-Z-Flo Ziram 76WP, Miller's Ziram and 95W; Wood Ridge Ziram; Cuman; Chempar Ziram 76WP; Corozate; Vancide MZ-96 and MZ Flowable; Shepard Chemical Ziram; Samincorp Ziram.

Fungicides of Less General Use

These chemicals include a large number of products with limited use. See also Disinfectants; Grain Preservatives; Lawn Fungicides; Other Soil Treatments (including Nematicides); Table 1, Soil-disinfesting Chemicals; Wetting, Spreading, and Sticking Agents (Surfactants); and *Seed Treatments* in another section of this book.

Acetic acid--A liquid food and grain preservative used to prevent spoilage in storage bins and elsewhere. Formerly applied to some extent as a soil drench to control damping-off (seedling blights) of evergreen seedlings. See also Grain Preservatives.

Amobam--A liquid foliar and soil fungicide containing 42% diammonium ethylene bis (dithiocarbamate). Used in a tank mix with zinc sulfate to form zineb. Controls damping-off, some foliar leaf spots and blights, rusts, anthracnoses, and other diseases for which zineb is registered.

Bacticin--A liquid used as a paint to eradicate crown gall tumors on stone fruits, walnut, and other woody plants. Bacticin is applied directly to galls on established plants. It contains 0.463% 4-xylenol m-cresol as the active ingredient.

Binapacryl (Morocide)--An effective, long-lasting miticide-powdery mildewicide with low use hazard for application to certain woody plants such as fruit trees, grapes, and walnuts. Binapacryl is not poisonous to beneficial insects. It is available as dusts, a 50% wettable powder, and a 4% emulsifiable concentrate. Binapacryl contains 2,*sec*-butyl-4,6-dinitrophenyl-3-methyl-2-butenoate as the active ingredient.

Borax (97% sodium tetraborate decahydrate)--Used somewhat as a postharvest wash for certain fruits and as a dip for sweet potato roots. Borax is applied dry to freshly cut pine stumps to prevent *Fomes annosus* root and butt rot. It is also added to boron-deficient soils; usually in combination with a fertilizer.

Bromosan--A systemic turf fungicide for control of Sclerotinia dollar spot, Rhizoctonia brown patch, copper spot, and Helminthosporium-incited diseases. Contains 16.67% diethyl 4,4'-o-phenylenebis [3-thioallophenate] and 50% thiram as its active ingredients.

Calo-clor and Calo-Gran contain a mixture of calomel (mercurous chloride) and corrosive sublimate (mercuric chloride or mercury bichloride) and are sold for use by certified golf course superientendents *only*. These products are sold to control snow molds (Fusarium patch, Typhula blight) on golf course greens, tees, and aprons. These fungicides were also formerly used to control Rhizoctonia brown patch, Sclerotinia dollar spot, and other summer turfgrass diseases. Calomel was once used as a dip for gladiolus corms to control Fusarium yellows and scab.

CM-19--A fungicide for controlling Botrytis or gray-mold blights of ornamentals in greenhouses. Contains 17% phenylphenols and related aryl phenols and 2% octyl-and related alkylphenols.

Dichlone (Phygon, Phygon XL, Phygon Seed Protectant, Arcadian Diclone)--A foliar and seed treatment fungicide for certain fruits, vegetables, and roses. Closely related to chloranil. Contains 50% 2,3-dichloro-1,4-napthoquinone as its active ingredient. Dichlone is not widely used at present. It may be phytotoxic and is irritating to individuals with sensitive skin. See also *Seed Treatments*.

Dithianon (Delan, Delan-Col)--A foliar fungicide with great tenacity. Effective against many fruit diseases but NOT against powdery mildews. Contains 2,3-dicyano-1,4-dithiaanthraquinone as the active ingredient.

Dowicide A--A post-harvest fungicidal treatment for several fruits, vegetables, and their containers. It contains 97% sodium o-phenylphenate (tetrahydrate).

Dowicide B--A liquid fungicide used as a dip to treat gladiolus corms and other bulbs, tubers, and roots. It contains 85% sodium 2,4,5-trichlorophenate.

Dowicide 1--A disinfectant and post-harvest fungicidal dip (in wax) for commercial treatment of certain vegetables, fruits, and their containers, e.g., crates, hampers, etc.

Du-Ter Fungicide (or TPTH)--A broad-spectrum, persistent, foliar fungicide with excellent sticking qualities, that contains 47.5% triphenyltin hydroxide as its active ingredient. It is excellent for controlling early and late blights of potato, Cercospora leaf spots of sugarbeets and peanuts, numerous foliar diseases of pecan, leaf blights of carrot, and is promising for use on soybeans and other crops. Du-Ter is available in a water-soluble bag and can be applied through sprinkler irrigation equipment.

8-hydroxyquinoline materials include 8-quinolinol sulfate, 8-hydroxyquinoline (oxyquinoline) sulfate, benzoate and citrate. These systemic soil and foliar fungicides are sold as Sunox, Fulex A-D-O (Anti-Damping-off Formula), Bioquin 700, Wilson's Anti-Damp, Aceto 8-hydroxyquinoline Sulfate. Useful for controlling several orchid diseases and for preserving cut flowers, and as a soil drench to control damping-off of many kinds of seedlings. Cellu-conc contains 1.5% copper 8-quinolinolate. It is used as a wood preservative for picking boxes, baskets, crates, and other containers.

Elgetol, DNC--A combination fungicide-insecticide-herbicide containing sodium dinitro-o-cresylate; used as a dormant fruit spray for chemical blossom thinning; also as an eradicant ground spray for controlling apple scab, grape black rot, and similar diseases where the causal fungi overwinter in fallen leaves. Elgetol also inhibits cedar-apple gall rusts on junipers.

Ferrous (iron) sulfate, Copperas--Used as a foliar spray, capsules placed into the trunk, or as a ground treatment in combination with sulfur to control chlorosis resulting from an insufficiency of iron.

Formaldehyde (formalin)--See under Disinfectants and Table 1, Soil-disinfesting Chemicals.

Glyodex--A wettable powder fruit fungicide containig 22.5% dodine and 37.5% glyodin. Used mostly by commercial apple growers to control scab and fruit rots.

Glyodin (Glyoxide)--A protective foliar fungicide for apples, cherries, and certain ornamentals with excellent wetting and sticking properties. It is often mixed with benomyl, dodine, or other fungicide. Glyodin, which also suppresses certain mites, contains 2-heptadecyl-2-imidazoline acetate as the active ingredient.

Harven, DHA--A post-harvest fungicide containing the sodium salt of dehydroacetic acid (DHA). Used as a dip or spray for controlling rots of certain processed fruits and vegetables. Formerly applied as a dip or wrapper impregnant.

Hexachlorobenzene (HCB)--A dust, slurry, or liquid seed treatment fungicide used primarily on cereals to control smuts. It is often combined with captan, maneb, thiram, or other fungicide to control seed rot and seedling blight fungi. See *Seed Treatments* for trade names and diseases controlled.

Kromad--A broad-spectrum, contact, turf fungicide containing 5% cadmium sebacate, 5% potassium chromate, 1% malachite green, 0.5% auramine, 16% thiram, plus urea, ferrous sulfate, and wetting agent. See also Lawn Fungicides.

Listerol Household Disinfectant--An aerosol containing a number of different chemicals including 55.53% ethyl alcohol. See Disinfectants.

Lysol--A liquid mixture of crude cresols, sometimes used for treating gladiolus corms. A 5% solution is a good disinfectant for tools. See also Disinfectants.

Methocel (Seed-Coat)--A powder or fiber containing methyl cellulose used as a sticker in seed treatment and for pelleting seed such as onions.

Nabam (Dithane D-14, F & B Nabam 22, Ortho Nabam Liquid Spray, Green Cross Thiogreen Liquid Fungicide, Niagara Nabam Solution, Nabam Liquid Fungicide, Chem-Bam)--Usually sold as a liquid fungicide and containing disodium ethylene-1,2-bisdithiocarbamate as the active ingredient. Nabam is mixed with zinc sulfate to form zineb and is used as a foliar spray or soil drench to control fungal diseases of vegetables, certain fruits, turfgrasses, and ornamentals. Dithane A-40 is a soluble form containing 93% nabam.

Natriphene--A foliar and soil fungicide containing 100% sodium salt of 2-hydroxydiphenyl. Used as a drench to control damping-off (seedling blights) of ornamentals, especially orchids.

Nematicide--See Table 1, Soil-disinfesting Chemicals and Other Soil Treatments (including Nematicides).

Niacide M--A wettable powder fungicide used by commercial apple and pear growers in cover sprays for controlling a variety of fruit spots and rots. The active ingredients include 48% manganous dimethyl dithiocarbamate, 12.4% thiram, 2.4% manganous benzothiazylmercaptide, and 2.2% 2,2'-dithiobisbenzothiazole.

Niaprex--A wettable powder fungicide for commercial apple growers that contains 32% manganous dimethyl dithiocarbamate, 1.6% manganous benzothiazylmercaptide, 8.27% thiram, 1.47% 2,2'-dithiobisbenzothiazole, and 10.84% dodine.

Omazene--A foliar fungicide containing copper dihydrazinium sulfate. Used somewhat to control black spot and powdery mildew of roses. May be phytotoxic.

Oxycarboxin (Plantvax-5L, Plantvax-75W Systemic Fungicide)--A systemic fungicide closely related to carboxin. Contains 5,6-dihydro-2-methyl-1,4-oxathiin-3-carboxanilide-4,4-dioxide as the active ingredient. Oxycarboxin controls a wide range of rusts attacking flowers, woody plants, vegetables, fruits, and turfgrasses when applied to seed, soil, or foliage.

Oxythioquinox (Morestan)--A long-lasting, contact, combination insecticide-miticide-powdery mildewicide primarily used on certain flowers, shrubs, strawberries, tree fruits, and other woody plants. Sold as a wettable powder containing 25% 6-methyl-2,3-quinoxalinedithiol cyclic s,s-dithiocarbonate as the active ingredient. May be phytotoxic to certain plants in hot weather.

Parinol (Parnon)--A liquid concentrate fungicide specific for control of powdery mildews of non-bearing apple trees, grape vines and certain ornamentals including roses and zinnias. Parinol contains a,a-bis (p-chlorophenyl)-3-pyridinemethanol as the active ingredient. It is also available as dusts. You only have to cover one leaf surface to get protection.

Piperalin (Pipron)--A liquid concentrate protectant-eradicant fungicide that contains 82.4% 3-(2-methylpiperidino)propyl 3,4-dichlorobenzoate. Piperalin controls powdery mildews of certain ornamentals (e.g., chrysanthemums, dahlias, lilacs, phlox, roses, zinnias), catalpa, and other plants. Greenfield Rose Ornamental Disease Control contains Pipron and maneb.

Polytrap-A fungicide for control of powdery mildew of roses. Contains 75% polyisobutylene.

Propionic acid--Liquid grain preservative often blended with acetic or another acid. See Grain Preservatives.

Soil Disinfestants, Fumigants, Fungicides--See Table 1, Soil-disinfesting Chemicals.

Spectro Turf Fungicide--A blend of a contact and systemic fungicide for control of Sclerotinia dollar spot, Rhizoctonia brown patch, Helminthosporium leaf spot diseases, and copper spot. It contains 2,4-dichloro-6-(o-chloroanilino)-s-triazine (33.33%) and diethyl 4,4'-o-phenylenebis [3-thioallophanate] (16.67%) as the active ingredients.

Spray lime--Spray grade, finely divided calcium hydroxide. Used in making bordeaux mixture and as a diluent for certain dusts, e.g., Copper-Lime Dust. Also used as a safener in certain sprays. To be effective, spray lime must be freshly made and uncarbonated.

Spray Sticker, Spreader, Spreader-Activator, Spreader-Sticker--See Wetting, Spreading, and Sticking Agents (Surfactants).

TCMTB (Busan 30 and 72, Cover-Up L, Thiogen, Protector 3L)--Contains 2-(thiocyanomethylthio)benzothiazole as the active ingredient. TCMTB is used mostly as a seed protectant fungicide for small grains and conifers, and as a bulb and corm dip for gladiolus and other ornamentals. It may be phytotoxic. See also *Seed Treatments*.

Terramycin--An antibacterial antibiotic containing oxytetracycline. Also sold as Mycoshield. Useful in controlling bacterial spot of peach and apricot. For use *only* by commercial growers.

Triforine--A foliar, systemic fungicide that gives excellent control of powdery mildews, scabs, rusts, fungus leaf spots, blights, rots, and other diseases of ornamentals, fruits, and vegetables. Triforine contains N,N'[1,4,piperazinediyl-bis-(2,2,2-trichloroethylidene)bis [formamide] as the active ingredient.

Trimanzone--A wettable powder fungicide for foliar use on vegetables that contains 60% maneb, 10% zineb, and 10% ferbam.

Triziman--A wettable powder fungicide for foliar spraying of vegetables. It contains 70% maneb and 10% zineb.

Zinc sulfate--Used with nabam and Amobam to form zineb; also used to control zinc deficiency problems. It is available largely as a 25.5% flake form (easily dissolved in water but tends to harden in storage) and as a 36% monohydrated form.

Disinfectants: There are a number of different chemicals that are used to kill bacteria and fungi on tools, equipment, potting tables, empty greenhouse benches, pots, flats, other containers, storage areas, and hydroponic equipment. These include dipping, brushing, or spraying with 70 to 100% alcohol (grain, rubbing or wood); 37 to

40% formaldehyde (1 pint in 5 gallons of water); Lysol; Listerol Household Disinfectant; potassium permanganate; and household bleach or sodium hypochlorite (Clorox, Purex, Sunny Sol), 1 pint of bleach in 1 gallon of water. Several commercial disinfectants are available. These include:

Bardac-22--Used for treating storage areas, tools, and equipment. It contains 50% didecyl dimethyl ammonium chloride and 20% isopropanol.

Germ-I-Tol--Used for treating storage areas and equipment. It contains 50% alkyl dimethyl benzyl ammonium chloride.

LF-10 (Amphyl)--Used on greenhouse benches, potting tables, walks, tools, flats, plastic pots, and automatic watering systems. A 65% solution containing a mixture of potassium ricinoleate, o-benzyl-p-chlorphenol, isopropyl alcohol, tetrasodium ethyleneamine, tetraacetate, and alcohol. Not effective against resistant resting bodies of some fungi.

Hyamine materials show germicidal effectiveness against a wide range of microorganisms. They contain quaternary ammonium compounds and are also used as antiseptics, germicides, algacides, detergent-sanitizers, and deodorants.

Physan--Used for treating storage areas, tools, and equipment. It contains 10% each of n-alkyl dimethyl benzyl ammonium chlorides and n-alkyl dimethyl ethyl benzyl ammonium chlorides.

Roccal--Used for treating potato storage areas and equipment. It contains 10% alkyl dimethyl benzyl ammonium chlorides.

Grain Preservatives: These are liquids containing propionic acid or mixtures of it with related acids (e.g., acetic acid) that allow harvesting and storage of high-moisture grain to be utilized for animal feed *only* without the problem of post-harvest spoilage from storage molds (primarily species of *Aspergillus* and *Penicillium*). Sold under such trade names as Aceto Propcorn, ChemStor and ChemStor III, Grain Storer P, Ortho-Guard G.P., Grain Treat, and Sentry. These products are NOT for treating grain that might be used for seed, malting purposes, or human consumption. Treated grain is reduced to sample grade due to persistent odors from the chemical treatment.

Lawn Fungicides: These are usually formulated as multipurpose mixtures to control a number of lawn and fine turfgrass diseases. The more widely available and used products include anilazine (Dyrene), chlorothalonil (Daconil 2787), Kromad, Fore, Tersan LSR and 1991 Turf Fungicides, Bromosan, Spectro, thiophanate materials (Fungo, Topmec 70W Turf Fungicide, Cleary's 3336, Chipco Spot Kleen, Scotts ProTurf systemic fungicide), Acti-dione Thiram, Sears Lawn Fungicide, Scotts ProTurf and Lawn Disease Preventer fungicides. Turf fungicides that control one to several diseases contain cadmium (Caddy, Cadminate, Cad-Trete, Puraturf 177, Vi-Cad), zineb, maneb or mancozeb, and others. See also Commonly Used Fungicides and Fungicides of Less General Use.

Surfactants (Wetting, Spreading, and Sticking Agents): These materials are added to spray mixes to help keep the pesticide in suspension, improve cohesiveness of the spray, and increase wetting of leaves, fruits, and stems. They are most useful when spraying hard-to-wet foliage such as that of conifers, broadleaf evergreens, boxwood, euonymus, carnation, gladiolus, iris, narcissus, peonies, roses, cabbage, onions, peas, and peppers.

A few commercial spreader-stickers (extenders) available for tank mixing include Aqua T Non-ionic Organic Wetting Agent, Agway Spreader-Sticker, Bio-Film Spreader-Sticker, DuPont Spreader-Sticker, Chevron Spray Sticker, Citowett Plus, Filmfast Spreader-Sticker, Miller Nu-Film-P and -17, De-Pester Spreader-Activator, Sprint-38 Spreader Sticker, Triton B-1956, and Plyac Non Ionic Spreader-Sticker.

Commercial spreaders and spreader-activators include Ortho Chevron Spreader, Chipco and Rhodia Spreader-Activator, Flo-Wet, Multi-Film L and X-77, Ortho X-77 Spreader, Pinoline, Sure Spred, Tween 20, Surfactant II, Triton AF and CS-7, Fluxit, Sanomerse 80, Penex, Sur-Ten Wetting Agents, and Activate 107.

Some common stickers include Goodrite PEPS, De-Pester Sticker, and Exhalt 800.

The fungicide or other pesticide label should indicate restrictions in selection of compatible surfactants. Use these commercial preparations according to label directions. The addition of excess wetting or spreading agent may cause excessive runoff and result in a poor spray deposit.

Soil Treatment Materials and Methods

The purpose of soil treatment (disinfestation) is to kill disease-inciting organisms (i.e., bacteria, fungi, nematodes, mycoplasmas), viruses, insects, and weed seeds. This eliminates the need to change soil in greenhouses, nursery beds, cold frames, hot beds, and other plant beds.

Soil can be sterilized (that is, disinfested or pasteurized) or fumigated easily using either heat or chemicals. Heat is usually the most effective in greenhouses since it kills all types of pests. Many chemicals are quite selective and kill only nematodes or fungi at normal application rates (Table 1).

SOIL FUMIGANTS--In recent years a number of chemicals have been formulated as liquids, granules, or gels to be applied in the soil. Most of these chemicals become gases and diffuse in soil to effect the kill. They are usually applied to soil several days or weeks before planting. Certain fumigants move through the soil slowly and require only a water "seal" after application. Other fast-acting or very toxic chemicals (e.g., methyl bromide and chloropicrin) must be confined with a gas-proof tarp made of polyethylene or other covering to retain the fumes.

The most useful fumigants to control nematodes plus the fungi and bacteria that cause wilts, damping-off, root and crown rots, and other diseases include chloropicrin ("tear gas"), methyl bromide, metham or SMDC, dazomet or DMTT, MIT (Vorlex), and Bedrench. These chemicals are often termed "biocides" because they are nonselective, killing essentially all organisms in the soil. All of these materials should be used *strictly* according to the manufacturer's recommendations. Observe all safety precautions listed on the label.

SOIL FUNGICIDES--These are applied as dusts or powders and blended into soil, soil sprays, and drenches, or as granules. Such fungicides control damping-off, seedling blights, crown and root rots, wilts, and other diseases. These include captan, benomyl, Botran, chloroneb, fernaminosulf, captafol, ferbam, etridiazol, Polyram, thiabendazole materials, PCNB, thiram, zineb, ziram, carboxin, 8-hydroxyquinoline materials, Dithane A-40, folpet, and thiophanate compounds.

GENERAL PRECAUTIONS AND SUGGESTIONS

Soil condition. Soil must be loose and easily crumbled to a depth of least six inches (the deeper the better) so it can be thoroughly penetrated by heat or chemicals. All lumps, trash, and clods should be broken up, and crop residues—especially large, diseased roots—should be removed or be well decomposed. Soil should be well mixed and in good seedbed condition when treated (moist enough to permit good seed germination—will just hold its shape when squeezed in the hand). Do *not* treat when soil is excessively dry, wet, or too cold (below 50° to 55° F).

Soil amendments. All soil amendments (e.g., manure, peat moss, compost, other humus material, sand) must be added before treating. It is especially important that organic matter be well decomposed.

Treating tools. When using steam or methyl bromide, treat tools (hoes, rakes, trowels, markers, shovels, spading forks), clay pots, flats, and rubber footware by laying them on top of the soil and under the gas-tight cover. Otherwise, dip or swab in a formaldehyde solution (1 pint in 5 gallons of water) after each use in contaminated soil and before using in treated soil. Boards or concrete at the bed edges should also be treated.

Avoid reinfestation of treated soil. Do *not* transplant seedlings, cuttings, or other plants from untreated or contaminated soil into disinfested soil. Soil is easily recontaminated by nonsterilized flats or pots, tools, and other equipment containing small bits of untreated soil, and contaminated water spattered by careless watering. Also, guard against disease-causing organisms in and on seed and other plant materials, unsterilized compost or manure, or gardener's hands and feet.

Wait before planting. After steaming, wait a day or two before seeding or planting. When chemicals are used, it may take 2 to 4 weeks to aerate soil before it is safe to plant. (See "Application and Remarks" under specific chemicals in Table 1. Soils high in organic matter or clay, excessively wet, or treated at low temperatures may retain the chemical at toxic levels for even longer periods.

Follow the manufacturer's directions on the label. A week after treating with a soil fumigant, work soil at least once to a depth of several inches to allow gas to escape. Control is best in light sandy-loam soils. Heavy clay and muck (peat) soils require 2 to 3 times the amount of fumigant used on sandy loams. Loose peat soils give little or no response to many soil fumigants, even at high rates of application. Excellent literature on calibration of equipment is available from fumigant suppliers. Fumigants are marketed as liquids, granules, and gases.

OTHER PRECAUTIONS

1. *Temperature.* Most soil fumigants require that the soil temperature at the 4- to 6-inch depth be 50° to 60° F and 80° to 90° F at the 3- to 5-inch level to permit optimum gas dispersion. Certain soil fumigants containing dichloropropenes can be used successfully at soil temperatures as low as 40° to 45° F.

2. *Time for treatment.* Late summer or early fall is usually the ideal time for chemical treatment of soil; crops have been harvested and soil temperatures are suitable for fumigation.

3. *Safety.* When handling soil fumigants follow these precautions:

   a. *Do not inhale fumes.* Handle fumigants only in open air and wear an approved respirator. Do *not* breathe the vapors. Chemicals are often irritating to the membranes of mouth, nose, and throat. If you inhale a fumigant, get to fresh air immediately and call a doctor. If breathing has stopped, give the patient artificial respiration. Keep the patient quiet and obtain medical attention as soon as possible.

   b. *Wear safety goggles* to protect the eyes. If eyes are accidentally contaminated, flush them with flowing water for at least 15 minutes and then consult a physician or Poison Treatment Center.

   c. *Do not spill chemicals on skin, clothing, or shoes.* If a spill occurs, wash skin promptly with plenty of soap or detergent and water. Remove affected clothing and shoes immediately. Clothes should be washed and shoes aired until all odor of fumigant has gone.

d. *Never* attempt to siphon fumigant or other pesticide by mouth suction since they are highly corrosive to mucous membranes and swallowing the chemical may kill you. If a fumigant is accidentally swallowed, produce vomiting (take a tablespoonful of salt in a glass of warm water or drink soapy water). Repeat until the vomit fluid is clear. Then call a physician and keep the poison victim still and quiet.

e. *Corrosion.* These materials are corrosive to certain metals, e.g., aluminum, copper, magnesium, zinc, and their alloys. Rinse application equipment with kerosene or fuel oil right after use. Do *not* use water.

f. *Proper storage.* Store fumigants in tightly closed, original labelled containers in a cool, dry place away from food and feed, and behind locked doors. Keep out of inhabited dwellings and away from heat and open flame. Avoid freezing.

g. *Always follow manufacturer's directions carefully.* Note recommended dosage, interval to avoid excessive residues or injury, type of covering if needed, and method of application.

h. *Do not damage plants.* Most fumigants, especially gaseous ones (e.g., metham or SMDC (Vapam), Dazomet or DMTT, D-D, EDB, MIT (Vorlex), chloropicrin, formaldehyde, and methyl bromide) *cannot be used* in a greenhouse or other confined area where living plants are present. Fumigants used outdoors should not be applied close to valuable plants, e.g., within 5 feet of shrubs or the drip line of trees. Growers should post warning signs when using dangerous chemicals in a greenhouse or other confined area.

   Use of soil disinfestants in alkaline soils may cause a phosphorus deficiency in certain plants. In soils low in available phosphorus, work into the soil 10 pounds of superphosphate per 1,000 square feet before fumigation.

   Fumigation may temporarily raise the level of ammonia nitrogen and soluble salts in the soil. This is most likely when heavy rates of fertilizer and fumigant are applied to soils that are cold, wet, acid, or high in organic matter. To avoid injury to plants, fertilize as indicated by a soil test made after fumigation. Ammonia injury and nitrate starvation are avoided by using only fertilizers containing nitrate nitrogen (at least 30% N) until after the crop is well established and the soil temperature is above 70° F. Liming highly acid soils before fumigation stimulates nitrification and reduces the possibility of ammonia toxicity. Adequate amounts of calcium, magnesium, and phosphorus in the soil should be maintained, based on a soil test.

i. *Further precautions.* See Table 1, "Application and Remarks."

Other Soil Treatments (including Nematicides)

These chemicals are usually applied by licensed commercial applicators as a spray, granules, or soil drench for both soil and established turf. Unlike soil fumigants (Table 1), the active ingredient does not move through the soil as a gas but as a liquid in soil water. It does not require a waiting period between application and transplanting or seeding a crop. Soil temperature is also not a limiting factor. Carefully follow all manufacturer's directions and precautions. With the exception of Diazinon, these chemicals are solely or primarily for use by commercial growers or profession applicators and not for home garden use.

1. *Aldicarb* (Temik). A highly toxic, long-lasting, granular, systemic combination insecticide-miticide-nematicide with some fungicidal activity for soil application to ornamental plants and some field crops. Contains 2,methyl-2-(methylthio)propionaldehyde-o-(methylcarbamyl)oxime as the active ingredient. *For commercial use only.*

2. *Carbofuran* (Furadan). A contact and systemic, long-lasting, broad-spectrum, soil and turf nematicide-insecticide-miticide that contains 2,3-dihydro-2,2-dimethyl-7-benzofuranyl methylcarbamate as the active ingredient. It is available as 10% granules (15-20 lb/A; 7-15-inch band on 40-inch rows) or as a flowable. Carbofuran is registered for use on some field crops, vegetables, shade trees, and pine seedlings. *For commercial use only.*

3. *Diazinon,* Science Diazinon, Spectracide, Lawn Insecticide with Diazinon, and Sarolex. Available as granules, dust, wettable powder, or liquid. A broad-spectrum insecticide-nematicide for application to turf and lawn grasses. Contains 0,0-diethyl o-(2-isopropyl-6-methyl-4-pyrimidinyl)phosphorothioate as the active ingredient. Diazinon is sold primarily as an insecticide, but is fairly effective against nematodes in sandy soils.

4. *Disulfoton* (Di-Syston). A long-lasting, seed and soil, systemic insecticide-miticide-nematicide for use on certain field crops, vegetables, turfgrasses, flowers, and ornamental trees and shrubs. Available as granules and as a liquid concentrate *for use only by commercial growers or professional applicators.* Disulfoton contains O,O-diethyl S-[2-(ethylthio)ethyl]phosphorodithioate as the active ingredient.

5. *Ethoprop* (Mocap, ProTurf Nematicide)—A highly toxic, contact, granular, long-lasting, broad-spectrum, soil and turfgrass nematicide-insecticide. It is registered for use on certain field crops, ornamentals, and turfgrasses. Ethoprop contains 10% or 15% O-ethyl S,S-dipropylphosphorodithioate as the active ingredient. For soil, apply 1 to 8 gal/A before or at planting time (incorporate thoroughly) or as a post-plant band application. For turf, distribute evenly over the established area to be treated, and drench in immediately using at least one-half inch or water. Carefully follow all manufacturer's directions and precautions.

6. *Fenamiphos* (Nemacur). A long-lasting, contact, soil and turf nematicide *for commercial or professional use only.* Contains ethyl-4-(methylthio)-m-tolyl isopropylphosphoramidate or ethyl 3-methyl-4-(methylthio)phenyl(1-methylethyl) phosphoramidate as the active ingredient. Available as granules and as an emulsifiable concentrate. Useful on certain field and vegetable crops. Applied as outlined for ethoprop (above).

7. *Fensulfothion* (Dasanit, Chemagro Dasanit Insecticide-Nematicide, Terracur P, and Dasanit Ornamental and Turf Nematicide). A highly toxic, long-lasting, primarily contact nematicide-insecticide for certain commercially grown turfgrasses, field crops, flowers, ornamental shrubs, foliage plants, and vegetables. Also used as a plant dip. Contains O,O-diethyl O-[4-(methylsulfinyl)phenyl] phosphorothioate as the active ingredient. Available as 15% granules and as a 63% liquid spray concentrate. Apply the same as for ethoprop (above); 1 to 3.3 gal/A of liquid concentrate or 20 to 184 lb/A of the granular product.

8. *Oxamyl* (Vydate L). A liquid systemic nematicide-insecticide-miticide containing 24% methyl-N,N'-dimethyl-N-(methylcarbamoyl)oxy-1-thiooxamimidate as the active ingredient. Applied as a foliar spray on woody plants; preplant soil incorporation; soil drench; root, corm and bulb dip; and in transplant water for use on certain vegetables and ornamentals. *Not for use in home plantings.*

TABLE 1. SOIL-DISINFESTING CHEMICALS--MATERIALS, BRANDS, CONTROLS, APPLICATION, AND REMARKS

TREATMENTS MATERIALS, BRANDS	*CONTROLS*	*APPLICATION AND REMARKS*
1. *Steam* Heat soil (6 inches deep or the coldest spot) to 180°-200° F (82°-93° C) for 30 min., or to 160° F (71° C) for 60 minutes.	All types of pests--fungi, most bacteria, nematodes, mycoplasmas, viruses, soil insects, mites, garden centipedes, and most weed seeds if moist.	Various methods are available: Pressure cooker (for small amounts), tank or vault, buried tile, perforated pipes on top of or in soil, or inverted-pan. Soil in benches or beds should be covered with a tarp. When steaming large quantities of soil, use a pressure between 15 and 100 pounds per square inch (psi).
Dry heat--Heat soil to 180° F (82° C) and keep at this temperature for 30 minutes.	All types of pests--the same as for Steam (above).	Place small quantities in an oven or use an electric soil pasteurizing box (e.g., Famco, Thermasoil).
2. *Multipurpose Chemicals* *Methyl Bromide;* Dowfume MC-2; Edco MBX; Bromex; Pestmaster Soil Fumigant-1; Brozone Soil Fumigant; Picride; Profume; Brom-O-Gas; Brom-O-Sol, MBC Fumigant; Tribrome; Weedfume; Bed-Fume; Meth-O-Gas; Nemaster. (Methyl bromide, usually with chloropicrin added.) Zytox and Rotox Gelled Soil Fumigant contain 70% methyl bromide and 28.7% EDB; Dowfume MC-33 and Terr-O-Gas 67 contain 67% methyl bromide and 33% chloropicrin. Trizone contains 60% methyl bromide, 30% chloropicrin and 9% propargylbromide.	Nematodes, grubs, garden centipedes, cutworms, wireworms, and other soil insects, weed seeds, damping-off, seedling blights, wilts, other soil-inhabiting disease-causing fungi, e.g., *Pythium, Fusarium, Phytophthora, Rhizoctonia, Sclerotinia, Verticilluum,* Actinomycetes.	Treatment is only for commercial applicators who are properly equipped. Gas in aerosol cans, cylinders, drums, or as solutions. Must apply with special applicator under a gas-proof cover. A fumigation period of 1 to 2 days is needed. A 1- to 2-week wait is normally required between treating and planting. Good in coldframes, greenhouses, turf, nurseries, and outdoor beds. *Very poisonous.* Carefully follow all manufacturer's directions. To kill soil fungi use 3 to 4 pounds/100 sq ft; for other pests 1 to 2 lbs. Do *not* use before planting onions, garlic, celery, carnations, salvia, snapdragons, holly, and multiflora rose. Most formulations contain a small amount of chloropicrin (about 1 or 2%) as a warning agent. Tractor-mounted machines with chisel-type applicators are used for field-scale operations. This equipment simultaneously lays a gas-proof cover. To disinfest tools, containers, and machinery, cover with a gas-proof cover and weight edges down. Apply 1 to 4 lbs/100 cubic feet. Leave cover in place for 2 to 3 days if the temperature is 50° to 59° F; 1 day if temperature is 60° F or above. A gas mask fitted with a black canister must be worn during application and when cover is removed. Do *not* use around living plants.
Chloropicrin; Picfume; Pic-Clor; Tri-clor; Chlor-O-Pic. (Tear gas or trichloronitromethane.)	Nematodes, damping-off, seedling blights, and other soil-inhabiting, disease-causing fungi and bacteria, weed seeds, and soil insects. Controls same range of pests as does methyl bromide (above).	Treatment is only for commercial applicators who are properly equipped. Liquid in pressure cans or cylinders. Apply with special injection equipment in holes 4 to 8 inches deep, at 8- to 12-inch intervals. Inject chemical into each hole and close by stepping on the hole (33-50 gal/A for light soils; 41-77 gal/A for heavy soils). After treatment, apply gas-proof cover or sufficient water to soak upper inch of soil to seal in gas. Maintain water seal or cover for at least 3 days. Do not plant in treated soil until all traces (odor) of chloropicrin has gone (12 days to 4 weeks). Use an approved chloropicrin mask, canister, and polyethylene gloves while working. Carefully follow all manufacturer's directions. Do *not* use around living plants.
Methyl isothiocyanate or *MIT:* Vorlex Soil fumigant (20% methyl isothiocyanate and 80% chlorinated C_3 hydrocarbons including dichloropropenes.	Nematodes, soil insects including symphylans, germinating weed seeds, bacteria, damping-off and seedling blight fungi, *Verticillium,*	Apply like chloropicrin (above) but use chisel spacings of 6 to 8 inches and 7 to 60 gal/A. Pack treated soil and apply a light water seal or plastic cover. Leave soil undisturbed for at least 7 days. Then aerate (cultivate) to prevent soil crusting. Do *not* plant for 1 to 4 weeks or until all odor is

TABLE 1. (CONTINUED)

TREATMENTS MATERIALS, BRANDS	*CONTROLS*	*APPLICATION AND REMARKS*
	and other soil-inhabiting, disease-causing fungi.	gone. Higher rates and cold or heavy soils require longer waiting periods (7 days for each 23 lb of active product). Carefully follow all manufacturer's directions.
Metham or *SMDC;* Stauffer Vapam Soil Fumigant; F & B Vapam (32.7% sodium N-methyl dithiocarbamate (anhydrous).)	Nematodes, soil-inhabiting and disease-causing fungi and bacteria, germinating weed seeds, and soil insects including garden centipedes; also a herbicide at higher rates of application.	Sprinkle liquid uniformly over soil with sprinkling can, hose proportioner, sprayer, or irrigation system. Or apply like chloropicrin (above) using 15-45 gal/A. Cover treated area with a tarp for 4 days after treating, or apply a water seal to upper inch of treated soil (15 to 20 gallons per 100 sq. ft). Do *not* treat more than 100 sq ft at a time before applying water seal. When top-treated soil has dried sufficiently, cultivate 1 to 2 inches deep. Do *not* plant until 3 to 4 weeks or more after treatment. Fall application is best. Do *not* use in greenhouses or close to where desirable plants are present.
Dazomet or *DMTT;* Mylone 25% G, 50% WP, 85% WP, Dust-50; Soil Fumigant M; Dazomet; Hopkins Mylone 50D; Crag Nemacide; Barber Preplant 50-D; Miller Mico-Fume 25-D (Mylone) (Tetrahydro 3,5-dimethyl-2H-1,3,5-thiadiazine-2-thione).	Nematodes, soil fungi, certain weed seeds, and soil insects.	Apply as a preplant drench (12 to 50 gal/A), powder or granules using a sprinkling can, sprayer, or fertilizer spreader. Disc, rake, or cultivate (rototill) into soil. Use for seed and plant beds. Cover treated area with gas-proof plastic cover or apply water seal as for Metham (above). Wait 3 to 4 weeks before planting. Fall treatment is best. Fumes are toxic to growing plants; greenhouses must be empty. Follow all manufacturer's directions and precautions.
Formaldehyde (Formalin); DuPont Formaldehyde Solution Parsons U.S.P. Formaldehyde. (Usually sold as a 40% solution in water and methanol.)	Damping-off, seedling blights, other soil-inhabiting and disease-causing fungi and bacteria, soil insects, and many soft or germinating weed seeds. Good disinfectant for tools, equipment, and storage areas. Also a seed disinfestant. Does NOT control nematodes.	Mix 3 tablespoons of formaldehyde in a cup of water and sprinkle over a bushel of soil (32 qts); 1 tablespoon in 1/2 cup of water treats a florist's flat of soil. Mix in very thoroughly with a shovel or hoe on a flat surface. Put treated soil in flats, pots, or leave in pile and cover with plastic, wet burlap, or canvas for 2 to 3 days. Drench soil in plant beds or seed flats. Use 1 cup in 3 gal of water. Apply slowly and evenly, 1/2 gallon/sq ft, using a sprinkling can. Cover soil. After 2 to 4 days remove cover, work soil, and plant when all odor is gone. Never use in a greenhouse or where plants are growing; fumes are toxic to plants.
3. *Chemicals Primarily for Nematode Control (Nematicides)*		
EDB; Ethylene Dibromide; Dowfume W-40 and W-85; Soilfume 40 and 85; Soilbrom 40, 85 and 90; Ortho Ethylene Dibromide; Bromofume; Garden Soil Fumigant; Pestmaster Fumigant EDB-85 (1,2-dibromoethane). Terr-O-Cide 15 is a mixture of 40% EDB and 15% chloropicrin; Terr-O-Cide 30 contains 36% EDB and 30% chloropicrin; Field Fume contains EDB and D-D.	Nematodes, wireworms, grubs, garden centipedes, and certain other soil-borne pests. Does little to control soil-borne fungi and bacteria.	Apply preplant, 6 to 8 inches deep at 10- to 12-inch intervals with a hand injector or special tractor-mounted equipment using 7 to 50 gal/A. Do *not* use around living plants or where onions will be grown within 3 years. Wait 2 to 3 weeks or more before planting. EDB is recommended for fall treatment only. Fumes are toxic to plants; greenhouses and other enclosed areas must be empty. Carefully follow all manufacturer's directions.

TABLE 1. (CONTINUED)

TREATMENTS MATERIALS, BRANDS	*CONTROLS*	*APPLICATION AND REMARKS*
1,3-D; D-D Soil Fumigant; Telone II, Vidden D; Olin OMA-D; Stauffer DD Soil Fumigant; Ortho D-D Soil Fumigant; Nemafume (mixed dichloropropenes). D-D/Pic, Terr-O-Cide 15D and Telone C are mixtures of 85% D-D and 15% chloropicrin. Terr-O-Cide 30D contains 70% D-D and 30% chloropicrin.	Nematodes, wireworms, garden centipedes and other soil insects, and certain other soil-borne pests. Gives poor control of bacteria and fungi.	Apply preplant about 6 inches under soil surface like EDB (above) at 10- to 12-inch intervals using 12-50 gallons per acre. Cover with a gas-proof plastic cover for 1 week. Do *not* plant until 2 to 3 weeks after treatment. Carefully follow all manufacturer's directions. Never use in a greenhouse or where plants are growing.
Dorlone, Olin OMA-fume, D-EDB (mixed dichloropropenes 78.9% and EDB 18.9%).	Nematodes and certain insects.	Apply as for EDB (above), using 12-24 gal/A. Do *not* use where onions or other sensitive plants will be grown within 1 to 4 years or on extremely heavy soils. Wait 2-3 weeks before planting. Fumes are toxic to plants. Carefully follow all manufacturer's directions.
Bedrench (81% allyl alcohol and 11.5% EDB).	Nematodes, weed seeds, and some damping-off fungi.	Apply as a seedbed drench like Metham (above). Considerable water and at least a 2-week waiting period is needed.
4. *Chemicals Primarily for Fungus Control (Fungicides)*		
Captan, etridiazol, thiram, Polyram, Banrot, fenaminosulf (Dexon), Polyram, Zyban, zineb, ferbam, ziram, benomyl, thiabendazole, chloroneb. (See also under these names.)	Seed rot, damping-off, seedling blights, caused by fungi in greenhouse (cutting) benches, flats, hot beds, pots, cold frames, and flower beds.	Apply as dust or spray uniformly over loose, fairly dry soil. Cultivate thoroughly into top 2-1/2 to 4 inches of soil. Seed can be planted immediately after treatment. May also be applied as a post-plant soil spray or drench. Use about 1 pint to 1 quart of prepared mix per square foot. Repeat at 5- to 20-day intervals if disease persists. Check and follow all label directions and precautions.
PCNB; Terraclor, Terracap, Terraclor Super-X, Terra-Coat L-205, PCNB wettable powders and dusts, Fungiclor. (Pentachloronitrobenzene.)	PCNB controls certain disease-causing fungi, e.g., *Rhizoctonia, Botrytis, Sclerotinia, Sclerotium.* (Etridiazol and fenaminosulf control water molds.)	Various application methods including suspension in transplant water, soil surface sprays or dusts, and dry mixing into upper 2 to 6 inches of soil. Sometimes mixed with etridiazol, fenaminosulf (Dexon), captan, ferbam, captafol, benomyl, or chloroneb. Thorough mixing with soil is essential. Follow manufacturer's directions regarding rates and methods of application.

THE SOYBEAN CYST NEMATODE PROBLEM

Dale I. Edwards, Richard B. Malek, Malcolm C. Shurtleff, and Barry J. Jacobsen[1]

Soybeans severely infected with the soybean cyst nematode (*Heterodera glycines* Ichinohe, 1952) are stunted and yellow or chlorotic, and may even be killed. Although damage is usually more severe on lighter, sandy soils, drastic losses have been observed on heavy soils that are typical of much of the Illinois soybean acreage. Damage can be greatly accentuated if infected soybean plants are exposed to drouthy periods and root-rotting fungi. A conscientious rotation with nonhost plants such as corn or sorghum and the elimination of weed hosts will tend to delay or perhaps prevent soybean cyst nematode populations from increasing to damaging levels. The soybean cyst nematode has been detected in most counties in the southern one-third of Illinois and in several counties in the central portion of the state (Figure 1). Undetected infestations are probably present in other counties. An awareness of the problem will aid in detecting new and potentially devastating infestations.

Symptoms and Identification

Unfortunately, symptoms of damage caused by the soybean cyst nematode on soybean plants and the appearance of infested fields are usually not specific enough to allow positive identification. However, some symptoms are quite suggestive of infection by this nematode, although these symptoms are not diagnostic. Heavily infected plants are stunted and may be yellow or chlorotic, particularly in soils of low fertility or when drouth conditions exist. Badly infested portions of a field may be oval to somewhat rectangular in outline, have a general yellowish cast, and show the most severe damage in the center with less damage toward the margin. *Many other conditions may cause the same or similar symptoms. Therefore, identification cannot be made on the basis of symptoms alone.* A grower should notify his county Extension adviser at once if he sees these conditions in his soybean fields, or contact an Extension plant pathologist at the University of Illinois, Urbana, Il. 61801. (telephones (217) 333-2478 and 333-1845). Special arrangements must be made for collecting and shipping of samples (see Report on Plant Diseases No. 1100, *Collecting and Shipping Soil Samples for Nematode Analysis).* Final identification cannot always be made with the unaided eye. The nematodes must be recovered from infested soil or plant roots and identified under a microscope or with a hand lens.

The Nematode and its Life History

Soybeans are infected by the *second-stage larva*—a microscopic (1/60 inch long, colorless worm. Larvae penetrate the soybean by puncturing the roots with a spear-like feeding structure—the *stylet*. Once inside the root, they migrate toward food-conducting tissues, where they feed and mature. Feeding alters the internal root structure, thereby interfering with normal root functions and ultimately causing plant damage. In approximately three weeks, mature males and females develop from the larvae.

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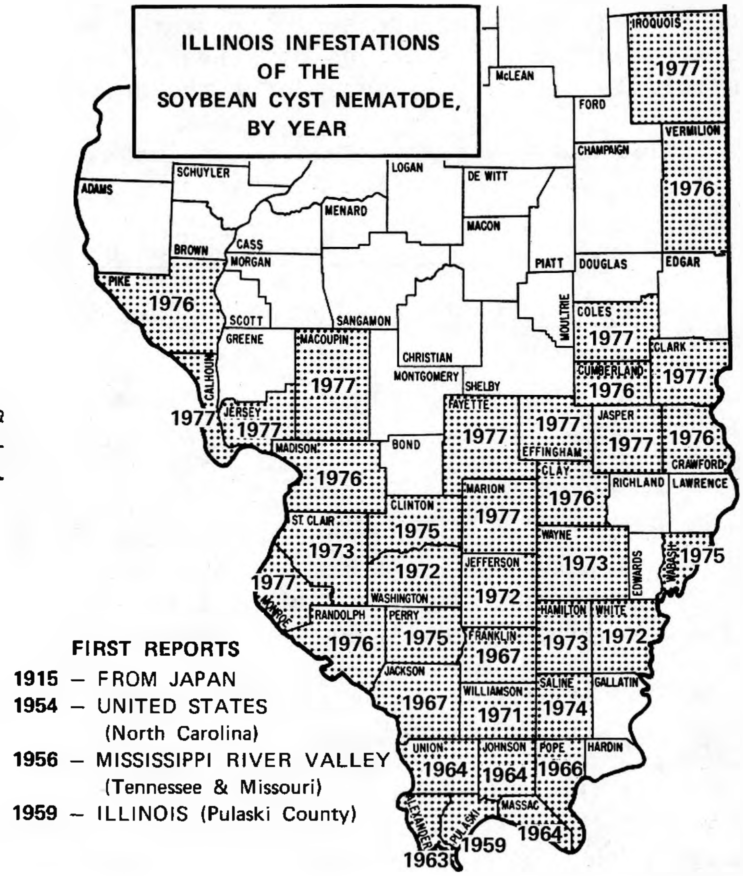

Figure 1. Illinois counties with known infestations of the soybean cyst nematode. The year of detection is indicated for each county.

The females enlarge greatly as they develop, becoming lemon shaped. They break through the root surface while remaining attached to the root by the head end. They lay some eggs in a jellylike mass in the soil, but retain most eggs within their swollen bodies. If an infected plant is dug at this stage, the females can be seen attached with the unaided eye as shiny, white, spherical bodies about the size of a pinhead. This is the so-called *white female stage*.

After death, the white female stage changes from white to yellow to brown—the *brown cyst stage*. By the time brown cysts are formed, the cyst (the altered female body wall) has become a protective structure containing many viable eggs. Encysted eggs can remain viable for several years in the absence of a host plant. In addition, the cyst wall protects them from drying and chemical action. For these reasons, the brown cyst stage is best suited for the spread of the nematode to new areas. One female will produce 200 to 600 eggs, and as many as five generations can be completed in a single growing season. Thus, if one cyst containing 400 eggs is introduced into a soybean field in the spring, over 10 trillion cysts could be produced in *one* growing season. The introduction of even a single cyst into a field, therefore, represents a potentially high nematode population that could cause noticeable damage within a short time.

There are four known races (designated Races 1, 2, 3, and 4) of the soybean cyst nematode. These races are characterized by their ability to reproduce on certain soybean varieties (Table 1). Race 3 is the common one found in Illinois, and resistant varieties, such as Custer and Franklin, can be grown without losses (see section on resistant varieties). Race 4, found first in Arkansas and later in Missouri and Tennessee, causes severe damage on Race 3-resistant varieties presently available. Damaging levels of Race 4 are known to occur in a number of Illinois counties and may be present in other areas of the state. Procedures for determining races of soybean cyst nematode infestations have been developed, and race determinations are made available as a grower service at the University of Illinois in Urbana-Champaign.

Table 1. Characterization of Known Races of the Soybean Cyst Nematode in the United States

Race[a]	Reproduction on key varieties				Susceptible check[b]
	Custer	Peking	P.I. 88788	P.I. 90763	
1	No	No	Yes	No	Yes
2	Yes	Yes	Yes	No	Yes
3	No	No	No	No	Yes
4	Yes	Yes	Yes[c]	Yes	Yes

[a] The numerical designation is based on chronological order of recognition, with Race 4 being the latest discovery.
[b] Any standard susceptible variety.
[c] Moderately resistant.

Experienced personnel can determine the most prevalent race present in a field by planting one or several small areas to a Race 3-resistant variety, such as Custer or Franklin, and to a susceptible variety. After 6 to 8 weeks, if no cysts appear on the roots of the resistant variety and cysts can be seen on the roots of the susceptible variety, the predominant Race is 3. Resistant varieties can then be grown and combined with crop rotation for control. If cysts appear on the roots of both the resistant and susceptible varieties, however, Race 3 is not the predominant race. At present there are no resistant varieties that could be grown in such fields without potentially severe losses. Crop rotation, possibly combined with application of a nematicide, is the only control alternative.

Host Plants

The host range of the soybean cyst nematode includes leguminous field crops, plus some ornamental plants and certain weed species that are susceptible and will increase nematode populations. These are underlined in Table 2. Other plants listed allow cyst production but are not often associated with soybean production in Illinois.

Means of Spread

Cysts occur throughout the root zone in the soil. Some accumulate on the soil surface. From there, they can easily be transported alone or with soil by many activities of man and by natural agencies. Cysts may be found in the mud adhering to farm implements, machines, vehicles, tools, workmen's shoes, or other mud-carrying items. The cysts may adhere to boxes, crates, cartons, and bags and can be moved in this way whether or not mud is present. Nursery stock, transplants, bulbs, corms, and root crops may carry cysts in adhering soil—even though the plants are not being attacked. Hay, straw, grain, or seed crops that carry dust or soil peds may also serve as carriers. Anything that moves through an infested field in contact with the soil is capable of picking up and transporting cysts. Equipment and contaminated soybean seed that has not been thoroughly cleaned appear to be the most important means of spread in Illinois.

Table 2. Host Plants of the Soybean Cyst Nematode That Grow in Illinois

Crop and Ornamental Plants	Weeds
Soybeans, cultivated and wild	Henbit
Beans, green (snap), bush, kidney, or lima	Hop-clovers
Lespedezas	Chickweed, common and mouse-eared
Vetch, common, hairy, or winter	Mullein, common
Lupines, white (ornamental species)	Beard-tongue (*Penstemon digitalis* Nutt.)
Clovers, crimson, scarlet, or alsike	Sicklepod
Sweetclover	Pokeberry or pokeweed
Birdsfoot-trefoil	Purslane
Crownvetch	Bittercress
Pea	Stinking-clover (*Cleome serrulata* Pursh)
Cowpea or black-eyed pea	Spotted (wild) cranesbill (*Geranium maculatum* L.)
Locust, black	Toadflax, Old-field (*Linaria canadensis* L.)
Bells of Ireland	Pigweed, winged (*Cycloloma atriplicifolium* Spreng.)
Borage *(Borago)*	Vetch, American, Carolina, or wood, (*Vicia micrantha* Nutt.)
Canarybirdflower	Bur-clover or toothed medic
Caraway	Prairie-trefoil
Chinese lanternplant	Dalea (*Dalea alopecuroides* Willd.)
Coralbells	Milkvetch, Canadian (*Astragalus canadensis* L.)
Cup-flower	Beggarticks [*Desmodium nudiflorum* (L.) DC., *D. marilandicum* (L.) DC., *D. viridiflorum* (L.) DC.]
Delphinium	Corncockle (*Agrostemma githago* L.)
Foxglove	Pea, perennial (everlasting)
Geranium	Hogpeanut [*Amphicarpa bracteata* (L.) Fern.]
Geum	Milk-pea [*Galactia volubilis* (L.) Britt.]
Horehound, common (*Marrubium vulgare* L.)	Wildbean [*Strophostyles helvola* (L.) Ell.]
Poppy	
Sage	
Snapdragon	
Sweet basil	
Sweetpea	
Verbena	

Note: Underlining indicates highly susceptible hosts.

Natural agencies may also be important in the spread of the soybean cyst nematode. Wind, runoff water, livestock, and wildlife may carry cysts into clean areas. Even water fowl and other birds feeding in infested fields may pick them up and carry them considerable distances.

Control

1. Quarantine. Preventing or slowing down the spread of the soybean cyst nematode is of primary importance to soybean producers throughout Illinois. One means of confining this pest is to enforce a quarantine. As of September 30, 1972, the United States Department of Agriculture discontinued the federal quarantine

against the soybean cyst nematode. A number of states, including Illinois, are continuing some form of quarantine. The Illinois Department of Agriculture plans to continue to administer and enforce the Illinois quarantine to prevent the spread within, and to some extent outside of, the state. Soil samples will be taken and processed, and new infestations will be delimited. Regulated areas will be revised to include new infestations when they are found.

Some states have already instituted quarantines against the states that have the soybean cyst nematode, allowing no seed beans or used farm machinery to enter unless certified as coming from soybean cyst nematode-free areas or cleaned to remove all soil capable of transporting the nematode. In response to the discontinuance of the federal quarantine, Canada has enacted strict regulations about importing seed beans, vegetable transplants, and nursery stock from soybean cyst nematode-infested states, unless these items can be certified as coming from an area free of the soybean cyst nematode. This certification must be based on a soil survey designed to detect this pest.

2. Resistant Varieties. Strides have been made in developing varieties that are resistant to the soybean cyst nematode. A highly resistant, black-seeded variety called Peking has been known for many years. Resistance for Races 1 and 3, derived from Peking, has been incorporated into eight released varieties: Custer and Franklin (Maturity Group IV); Dyer, Forrest, and Mack (Group V); and Pickett, Pickett 71, and Centennial (Group VI). Custer and Franklin are the only ones adapted to southern Illinois, although some Dyer, Mack, and Forrest have been grown successfully in the southern tip of the state. The U.S. Department of Agriculture, the Regional Soybean Laboratory at the University of Illinois at Urbana-Champaign, and state agricultural experiment stations are in the process of improving existing resistant varieties and developing new ones suitable for use throughout Illinois. Such public varieties, as well as some produced by private soybean breeders, should be forthcoming in the near future.

A black-seeded plant introduction (P.I. 88788) was found to be moderately resistant for Race 4 of the soybean cyst nematode. It is also highly resistant to the root-knot nematode. Breeding programs are under way to incorporate this resistance into superior agronomic varieties. Some advanced breeding lines with Race 4 resistance have already been tested by the USDA and the University of Illinois in southern Illinois.

The value of growing resistant varieties on land heavily infested with the soybean cyst nematode is illustrated by the following yields obtained in replicated field plots in Franklin County:

Year 1968

Variety		Yield (bu/acre)
Custer	(resistant)	38.1
Scott	(susceptible)	10.4
Clark 63	(susceptible)	8.7
Wayne	(susceptible)	5.7
Kent	(susceptible)	5.1

Year 1976

Variety		Yield (bu/acre)
Forrest[a]	(resistant)	45.5
Franklin	(resistant)	45.1
Custer	(resistant)	38.0
Mack[a]	(resistant)	37.7
Essex	(susceptible)	27.4
Cutler 71	(susceptible)	24.1

[a] Forrest and Mack are later-maturing varieties. Matured on October 20 in this test.

Occasionally, resistant varieties do not outyield susceptible varieties on land that is free of the soybean cyst nematode.

3. Crop Rotation. If resistant varieties are not available, especially for Race 4, rotation with resistant nonhost crops offers the next best control measure. Weed hosts must be kept out of fields during the rotation. For example, observations in Illinois have shown that volunteer Korean lespedeza, growing as a weed in an infested field, can maintain populations of the soybean cyst nematode in the absence of soybeans. A field experiment in Franklin County, Illinois, has demonstrated an increase of 6 bushels per acre following a one-year rotation with corn, a nonhost crop. However, to substantially reduce populations of the soybean cyst nematode, a rotation period of at least three years is advisable. Regardless of the rotation period used, soybeans should not be grown two consecutive years on infested land.

4. Chemical Control. Suitable application methods are available and about 20 chemicals (nematicides) have been tested in Illinois for control of the soybean cyst nematode. However, only a few of these are at present cleared by the federal Environmental Protection Agency for use to control nematodes attacking soybeans. Two nematicides, ethoprop (Mocap)[1] and phenamiphos (Nemacur),[1] are registered for use on soybeans. However, these chemicals have given somewhat erratic control in Illinois. In infested areas of the state for which resistant varieties have not been developed, chemical control must be considered in combination with crop rotation. Before chemicals are used, however, Extension Service personnel and specialists in nematology should be consulted to assure proper application rates and methods.

[1]Mention of a trademark or proprietary product does not constitute a guarantee or warranty of the product by the U.S. Department of Agriculture and does not imply its approval to the exclusion of other products that may also be suitable.

1978 Suggested Fungicide Guide | Fungicide Guide for COMMERCIAL VEGETABLE GROWERS

Vegetable fungicide tolerances and intervals approved by the Food and Drug Administration and the Environmental Protection Agency as of October 1, 1977, are presented in this publication. The tables on pages 2 and 3 give the tolerances in parts per million (ppm) and the number of days between the last application at normal rate and the harvest *or* they give the date of last application that will keep residues within tolerances set by the FDA.

The listing of a chemical for a crop does not necessarily constitute recommendation for control of a disease on that crop by the Illinois Cooperative Extension Service or the Agricultural Experiment Station. Specific recommendations are given on pages 4 to 7.

In some instances a tolerance (ppm) has been set but a definite interval has not been established. The absence of an interval does not necessarily mean that the fungicide may not be used on that crop. Use of the fungicide would require such restrictions as "do not apply after first blooms appear" or "do not apply after edible parts form."

In a few cases the interval and dosage have been established, but the allowable ppm residue has not been determined. Here again this does not mean that the fungicide may not be used on that crop. It does mean, however, that until a tolerance is established it must be considered to be zero. Zero tolerances are reviewed each year. Some are cancelled as the manufacturer supplies the EPA with additional data.

Growers must follow a disease control program that will assure the production of vegetables with no excessive fungicide residues. Vegetables marketed with residues exceeding FDA tolerances may be injurious to consumers, may be confiscated, and may cause the grower to be brought to court.

Growers have nothing to fear from the law so long as they use fungicides and other pesticides according to the current label only on the crops specified, in the amounts specified, and at the times specified. The safe grower keeps a record of the products and trade names used, the percentage of active ingredients, dilutions, rates of application per acre, and dates of application. The record sheet provided on page 8 is a convenient place to keep such information.

This circular will be revised each year. Be sure you have the most up-to-date copy.

Prepared by Barry Jacobsen and M. C. Shurtleff, Department of Plant Pathology

UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN COLLEGE OF AGRICULTURE COOPERATIVE EXTENSION SERVICE

Urbana, Illinois Circular 999 November, 1977

FUNGICIDE USES FOR VEGETABLES, APPROVED BY THE EPA, OCTOBER 1, 1977[a, b]

Crop	Benlate, 0.2-15 ppm	Captan (D) (See ppm below)	Bravo, 0.1-15 ppm	Difolatan, 0.1-15 ppm	Dyrene, 10 ppm	maneb, 4-10 ppm maneb with zinc salt	mancozeb[c] (See ppm below)	zineb, 4-25 ppm
Asparagus	..	root dip	..	..	..	A[d]	(0.1 ppm), A	A
Beans (dry, lima, snap) lima	14,[e] B (snap only) 28	(25 ppm), pp, 0[e]	7,[e] B (snap only)	..	..	0[e] 4 on limas or snap	..	7[e]
Beet, garden	..	(2 ppm-root, 100 ppm-greens), 0, pp	..	..	..	..	..	7(tops)
Broccoli	..	(2 ppm), pp	0[e]	..	..	(10 ppm), 3 or trim and wash	..	7
Brussels sprouts	..	(2 ppm), pp	0	..	..	7	..	..
Cabbage	..	(2 ppm), pp	0	..	..	(10 ppm), 7	..	7
Cantaloupe (muskmelon)	0	(25 ppm), 0, ph,[d] pp	0	0[e]	0[e]	5	(0 ppm in edible parts), 5[e]	5
Carrot	..	(2 ppm), 0	0	..	..	(7 ppm), 0	(2 ppm) 7, B (tops)	7(tops)
Cauliflower	..	(2 ppm), pp	0	..	..	0	..	7
Celery	(3 ppm), 7	(50 ppm), 0, pb	7	..	0	(5 ppm), strip and wash, 14	(5 ppm), 14	strip and wash, 14
Chinese cabbage	..	..	..	..	..	..	..	7
Corn, sweet and pop	..	(2 ppm), 10, B, pp	14, B[f]	..	..	..	(0.5 ppm-cob and kernel), 7 (5 ppm-fodder and forage, 0.5 ppm-ears)	0, B, C
Cucumber	(1 ppm), 0	(25 ppm), 0, ph, pp	0	0	0	(4 ppm), 5	(4 ppm), 7	5
Eggplant	..	(25 ppm), 0, ph, pb	..	..	..	0	..	0
Endive, escarole	..	..	..	..	..	(10 ppm), 7 and wash	..	10
Fennel	..	..	..	..	..	..	7	..
Kale, collard	..	(2 ppm), pp	..	..	..	(10 ppm), 10 and wash	..	10
Kohlrabi	..	..	..	..	..	0	..	(halfgrown)
Lettuce	..	(100 ppm), 0	..	..	..	(10 ppm), 7 (strip and wash)	..	10
Mustard greens	..	(2 ppm), pp	..	..	..	(10 ppm), 10 and wash	..	10
Onion	..	(50 ppm green, 25 dry), 0, ph	0	0	0	(7 ppm), 0	(0.5 ppm dry), 7, D	10
Peas	..	(2 ppm), pp	..	..	..	..	..	10, C
Pepper	..	(25 ppm), 0, pb, pp	..	..	..	(7 ppm), 0	E	0
Potato, Irish[d]	..	(25 ppm), 0, ph	0	0	0	(0.1 ppm), 0, C	(1.0 ppm), 0	0 and seed, C, pp
Pumpkin	..	(25 ppm), 0, pp	0	..	0	(7 ppm), 0	..	0
Radish	..	..	..	..	0	..	..	0
Rhubarb (greenhouse)	..	(25 ppm), 0	..	..	..	(10 ppm), 0	..	..
Spinach	..	(100 ppm), 0, pp	..	..	..	7 and wash	..	10
Squash	(1 ppm), 0	(25 ppm), 0, pp	0	..	0	(7 ppm), 5	(4 ppm), 5	5
Sugar beet[d]	(0.2 ppm-roots, 15 ppm-tops), 21	0	..	..	..	10, B, C, 14, no feeding restrictions	(2 ppm roots, 65 ppm-tops), B, 14	..
Swiss chard	..	0	..	..	..	..	..	10
Tomato	(5 ppm), 0	(25 ppm), 0, pp	0	0[g]	0	(4 ppm), 5, F	(4 ppm), 5	5
Turnip, rutabaga	..	(2 ppm), pp	..	..	..	10 and wash	..	(7 ppm), 7-tops
Watermelon	(1 ppm), 0	(25 ppm), 0, pp	0	0	0	5	(0 ppm edible parts), 5[e]	5

[a] No tolerances have been set for these fungicides on dill, horseradish, okra, parsley, and parsnip.
[b] The following abbreviations are used:
A = Post-harvest application to ferns only or to young plantings that will not be harvested.
B = Do not feed treated tops or forage to livestock.
C = Do not use treated seed or seed pieces for feed or food.
D = Do not apply to exposed bulbs.
E = Do not apply after fruit buds form.
F = To avoid damage, do not use on tender young plants.
pb = Plant bed treatment.
ph = Post-harvest spray or dip.
pp = Preplant soil treatment.
[c] Mancozeb is sold as Dithane M-45 and Manzate 200.
[d] Tolerances are not needed for pesticides applied only to the foliage and not translocated to the tubers or roots.
[e] Number indicates number of days between last application and harvest; 0 = up to harvest.
[f] Do not apply if crop is to be used for processing.
[g] Machine harvest only.

LABEL INFORMATION ON FUNGICIDES OF LESS GENERAL USE

Fungicide (tolerance)	Crops and use restrictions
Botran	**Beans** (snap) — white mold, 2 days to harvest. Do not feed forage to livestock. **Greenhouse tomato** — to harvest. Do not drench seedlings or newly set transplants. **Carrot** — post-harvest dip or spray, see label. **Garlic, Onion** — soil application before seeding or spray to soil around sets or bulbs. *Do not plant spinach* as follow-up crop in treated soil. **Leaf lettuce** (greenhouse) — 14 days[a] (do not apply to wilted plants or seedlings). **Head lettuce** — 14 days. **Celery** — 7 days. **Cucumber** (greenhouse) — see label. **Rhubarb** (greenhouse) — 3 days. **Potato** — 14 days (do *not* feed to livestock). **Sweet potato** — root dip and plant bed treatment. **Note:** Do not plant tomatoes as followup in treated soil. Don't use spent roots for food or feed. Post-harvest spray or dip as directed.
Copper fungicides[b]	
tribasic copper sulfate (Kobasic, Triangle, Tri-basic Copper Sulfate, etc.)	**Bean, beet, broccoli, cabbage, cantaloupe, carrot, cauliflower, celery, cucumber, eggplant, honeydew melon, lettuce, muskmelon, onion, pea, potato, pumpkin, radish, spinach, squash, tomato, watermelon.**
copper sulfate (many)	**Bean, broccoli, cabbage, cantaloupe, cassaba melon, cauliflower, celery, cucumber, honeydew melon, muskmelon, Persian melon, potato, pumpkin, radish, squash, tomato, watermelon.**
copper resinate (Citcop 4E, Cop-O-Cide, Emulsifiable Liquid Copper Fungicide)	**Bean, cantaloupe, cauliflower, chinese cabbage, cucumber, honeydew melon, lettuce, onion, pepper, pumpkin, squash, tomato, turnip, watermelon.**
copper ammonium carbonate (Copper-Count N)	**Bean, cabbage, carrot, crenshaw melon, celery, cantaloupe, cassaba melon, cucumber, honeydew melon, lettuce, muskmelon, pepper, Persian melon, potato, squash, tomato, watermelon.**
copper hydroxide (Kocide 101 and 404)	**Bean, cantaloupe, carrot, celery, cucumber, honeydew melon, muskmelon, pepper, potato, pumpkin, squash, tomato, watermelon.**
copper oxychloride sulfate (COCS, Copro 50 and 53)	**Bean, beet, broccoli, cabbage, cantaloupe, carrot, cassaba melon, cauliflower, celery, crenshaw melon, cucumber, eggplant, honeydew melon, lettuce, muskmelon, onion, pea, Persian melon, potato, pumpkin, spinach, squash, tomato, watermelon.**
bordeaux mixture (Acme Bordeaux mixture, Pattersons Bordeaux mixture, Bor-Dox, Ortho Bordo mixture, etc.)	**Cress, cucumber, eggplant, honeydew melon, muskmelon, Persian melon, potato, pumpkin, radish, squash, tomato, turnip, watermelon.**
Dexon	Cleared ***only*** for seed-treatment use on **beans, beets, corn, cucumbers, peas, spinach, sugar beets.** Do not use treated seed for food, feed, or oil. Slurry seed treatment for planting in light soils or soils high in clay or organic matter.
dinocap (Karathane)	**Cantaloupe (muskmelon), cucumber, honeydew melon, pumpkin, squash, watermelon** — 7 days. For control of powdery mildew only.
etridiazole (Terrazole, Truban)	Seed treatment: **Beans, peas, sugar beets.**
polyethylene polymer (Polyram) (0 ppm)	**Potato, sugar beet** — no time limitations. **Celery** — 14 days. **Cantaloupe, cucumber, tomato** — 5 days. Do *not* feed **sugar beet** tops to meat or dairy animals. **Celery** — strip, trim, and wash. Post-harvest application to **asparagus ferns.**
PCNB (Terraclor, Brassicol, Fungiclor) (0.1 ppm)	**Beans** — base of plants *before* blossoming, soil and seed treatment at planting, or foliar spray. Do *not* feed treated **Bean** vines to livestock. Do *not* apply after first bloom. **Broccoli, brussels sprouts, cabbage, cauliflower** — transplant solution (¾ pint per plant) or row treatment before transplanting. **Pepper, potato, tomato** — soil treatment at or before planting. **Tomato** (field use only) — transplant solution (½ pt. of 0.2% per plant). **Garlic** — soil and seed treatment at planting.
streptomycin (0.25 ppm)	**Celery, pepper, tomato** — plant beds only (200 ppm spray); **Potato** — seed-piece treatment only (100 ppm dip or dust). Soak cut seed pieces less than 30 min. **Beans** — seed treatment for halo blight control. Do not use treated seed for food or feed.
sulfur, lime, and lime-sulfur	Exempt when used with good agricultural practices. See label.
thiabendazole (Mertect)	**Sweet potato** — "seed" root treatment. Do not use treated pieces for food or feed. **Potato** — "seed" tubers only (1,500 ppm-20 sec. dip.
thiram, TMTD (0.5-7 ppm)	**Onion** — Furrow treatment. **Celery** — 7 days (strip, trim, and wash). **Sweet potato** — preplant root dip. **Tomato** — 0 days, for leaf spots and fruit rots. Seed treatment: **Beans, beets, broccoli, brussels sprouts, cabbage, cantaloupe, carrot, cauliflower, collard, corn, cucumber, eggplant, endive, kale, kohlrabi, lettuce, okra, onion** (bulb, seed, and set), **peas, pepper, pumpkin, radish, spinach, squash, swiss chard, tomato, turnip, watermelon.** WARNING: Do not use treated seed for food, feed, or oil.
triphenyltin (Du-Ter)	**Potato** — early and late blight. May be applied through irrigation systems (solid set or center pivot only).

[a] Number of days between last application and harvest.
[b] There are many other copper materials, but these are most widely available and labeled for use on vegetable crops. Exempt from tolerance if used with good agricultural practices; not exempt if used at time of or after harvest. See label.

CONDENSED FUNGICIDE RECOMMENDATIONS FOR DISEASES OF COMMERCIAL VEGETABLE CROPS FOR 1977

Vegetable	Diseases	Fungicide[a]	Remarks
Asparagus	Rust (RPD934)[b], leaf and branchlet blights	zineb, maneb, mancozeb, or Polyram	Apply to non-harvested fields *throughout* season to August 15; to harvested fields *after* cutting only. Apply at 7- to 10-day intervals. May combine with insecticides to control asparagus beetles, cutworms, etc. (Cir. 897).[b] Polyram on ferns only.
	Root rots	mancozeb, captan	Use as a preplant dip.
Beans (garden, wax, and lima)	Seed decay (RPD915), damping-off, and seed-borne stem blights and root rots	thiram, captan, Terrazole, or chloroneb plus insecticide	Treat seed any time if not previously treated by producer. Plant *only certified*, western-grown seed in warm soil above 65° F.
	Bacterial blights	fixed copper (2-3 lb. metallic/A.)	Apply at weekly intervals. Plant *only certified* western-grown seed.
	Rust, anthracnose, fungus leaf spots, pod and stem spots	maneb, zineb, or Bravo	Apply at 7- to 10-day intervals during moist weather. Combine with insecticides to control bean beetles, aphids, leafhoppers, blister beetles, etc. (Cir. 897).
	Mosaics		Use insecticides to control aphids (NHE-47)[b] that transmit the viruses. Kill aphids *before* they feed (Cir. 897). Control weeds in and around fields (Cir. 907).
	White mold	Botran, PCNB, benomyl	Apply to base of plants just before bloom, or at 25-50% bloom (benomyl). Do not feed treated vines to livestock.
Beets (garden and sugar), Spinach, Swiss chard	Seed rot (RPD915), damping-off, and seed-borne leaf spot and anthracnose	thiram or captan	Treat seed any time or buy treated seed. To control damping-off apply captan (5-7 lb. of 50% WP in 25-30 gal. water/A. or 25-30 lb. of 10% dust/A.) in furrow at planting time.
	Cercospora leaf spot (RPD951), downy mildew	zineb or fixed copper (2-3 lb. metallic/A.)	Apply every 1 to 2 weeks during rainy periods. May combine with insecticides to control aphids, leafhoppers, caterpillars, leaf miners, etc. (Cir. 897).
	Mosaics, virus yellows		Use insecticides to control aphids (NHE-47) and plant bugs that transmit the viruses. Kill insects before they feed (Cir. 897).
Broccoli, Brussels sprouts, Cauliflower, Cabbage, Chinese cabbage, Collard, Mustard, Kale, Kohlrabi, Radish, Rutabaga	Seed rot (RPD915), damping-off, black rot (RPD924), blackleg (RPD955), radish black root (RPD948), Alternaria blight	hot water, then thiram or captan	Buy western-grown seed. Sow *only* seed treated with hot water. Control cabbage root maggots, cutworms, cabbage worms, etc. (Cir. 897). Four-year rotation with non-crucifer crops.
	Wirestem (*Rhizoctonia*) (RPD902), damping-off, seed rot (RPD916), Botrytis blight (RPD942)	PCNB-captan mixture	Dust or spray on soil just before, at, or after planting seed. Follow manufacturer's directions.
	Clubroot (RPD923)	PCNB 75	Apply in transplant water or starter solution, ¾ pt. per plant (about 400 to 600 gal./A.). Do *not* use emulsion form of PCNB.
	Downy mildew, leaf spots, white rust (RPD960), anthracnose, Botrytis blight (RPD942)	maneb, zineb, or Bravo	Apply at 5- to 7-day intervals (3-5 days for radish) in wet weather. Use maneb in seedbed(2 lb./100 gal.). Good coverage important. May need spreader-sticker. May combine with insecticides to control aphids, cabbage worms, etc. (Cir. 897).
	Mosaics, black ringspot		Use insecticides to control aphids (NHE-47) and cabbage worms (NHE-45) that transmit the viruses. Kill insects *before* they feed — especially in seedbeds (Cir. 897).
	Brittle root (primarily horseradish)		Use insecticides to control leafhoppers that transmit the virus (Cir. 897). Apply when leafhoppers are *first* noticed. Additional applications may be necessary if infestation is severe.
Horseradish	Leaf spots	fixed copper	
Carrot, Parsnip	Seed rot (RPD915), damping-off	thiram or captan	Treat seed any time. May combine with insecticides.
	Aster yellows (RPD903)		Use insecticides to kill leafhoppers that transmit the mycoplasma, *before* they feed (Cir. 897). Begin when plants are 2-3 inches tall; apply weekly for 4 weeks. Control weeds in and around plantings (Cir. 907).
	Cercospora leaf spot, Alternaria leaf blight (RPD938)	captan, maneb, mancozeb, zineb, or Bravo	Apply at 5- to 10-day intervals in rainy periods. Thorough coverage essential. Start around June 15.

[a] Dosages: The quantity of material listed is the pounds of active (actual) ingredient to be applied to 1 acre unless stated otherwise (i.e., 3 lb./A.; 2 lb. 50% WP; 20 lb. 5% dust). Abbreviations used: A = acre; WP = wettable powder; pt. = pint(s); gal. = gallon(s); T. = tablespoon(s) (level); sq. ft. = square foot or feet.

[b] RPD = Report on Plant Diseases; NHE = Natural History Entomology publication. General references: Circular 897, Insect Pest Management Guide — Commercial Vegetable Crops and Greenhouse Vegetables; and Circular 907, Herbicide Guide for Commercial Vegetable Growers. Materials available in County Extension Offices.

CONDENSED FUNGICIDE RECOMMENDATIONS (continued)

Vegetable	Diseases	Fungicide	Remarks
Celery, Parsley	Seed rot (RPD915), damping-off, seed-borne blights	hot water, then thiram or captan	Treat seed just before planting or buy treated seed. If damping-off starts, spray plants and soil 2 to 3 times, 5-7 days apart. Use zineb (1 T./gal.). Three-year-old seed is free of late blight.
	Leaf blights and leaf spots	maneb, zineb, benomyl, Dyrene, Bravo, mancozeb	Apply every 7-10 days in field except during very dry weather.
	Mosaics, calico, ringspot		Use insecticides to control aphids (NHE-47) that transmit the viruses. Kill aphids *before* they feed (Cir. 897). Control weeds in and around plantings (Cir. 907).
	Aster yellows (RPD903)		Use insecticides to control leafhoppers that transmit the mycoplasma. Kill insects *before* they feed. Control weeds in and around plantings (Cir. 907).
Corn (sweet and pop)	Seed rot (RPD915), seedling blights, seed-borne root and stalk rots, leaf blights	Captan, zineb, Vitavax-thiram, or thiram *plus* insecticide	Treat seed any time or buy seed treated with both a fungicide and an insecticide (NHE-27).
	Bacterial wilt (RPD907)		Apply insecticides over row to control flea beetles (NHE-36) that transmit the wilt bacteria (Cir. 897). One to 6 sprays may be needed, 3 to 5 days apart. Start the day *before* corn comes up.
	Helminthosporium leaf blights	mancozeb, Polyram, or Bravo	Begin when disease first appears. Repeat at 7-day intervals or as required.
	Rust	zineb	Same as above.
Cucumber, Muskmelon (Cantaloupe), Pumpkin, Squash, Watermelon	Seed rot (RPD915), damping-off, angular and Alternaria leaf spots, Fusarium wilt, gummy stem blight or black rot, anthracnose, scab	captan, or thiram *plus* insecticide	Sow *only* certified, western-grown seed. Watering after planting with captan 50W (2 lb./100 gal. at 1 gal./125 sq. ft., every 5-7 days) controls damping-off. May combine with insecticides (Cir. 897) to control seed-corn maggots (NHE-27) in seedbed. Use 3- to 4-year rotation.
	Bacterial wilt (RPD905)		Use insecticides to control cucumber beetles (NHE-46) that transmit the causal bacteria. Kill beetles *before* they feed (Cir. 897). Applications needed from young seedlings to mature plants. Thorough coverage is essential.
	Anthracnose (RPD920), downy mildew (RPD927), scab (RPD928), blossom blight, leaf spots and blights (RPD918), fruit spots and rots, gummy stem blight or black rot	maneb, mancozeb, zineb, Bravo, Difolatan, Dyrene, or benomyl	Use captan or ziram (2-3 lb./100 gal.) on young plants. Apply at 7- to 10-day intervals from seedling emergence to vining. Start other materials *after* vines begin to run. Repeat at 5- to 10-day intervals to 7-10 days before harvest; keep new growth protected. May combine with insecticides to control cucumber beetles, aphids, vine borer, pickle worm, etc. (Cir. 897).
	Angular leaf spot (RPD919)	fixed copper (2-3 lb. metallic/A.) or soluble copper	Apply at 5- to 7-day intervals in warm, wet weather; or mix with zineb or maneb (2 lb./A.). Begin when plants start to vine or disease *first* appears.
	Mosaics (RPD926)		Use insecticides to control aphids (NHE-47) and beetles (NHE-46) that transmit the viruses (Cir. 897). Kill insects *before* they feed. Control weeds (Cir. 907).
	Powdery mildew (RPD925)	Karathane WD, benomyl (8 oz./100 gal.), Bravo *plus* spreader-sticker	Dust or spray. Thorough coverage essential. Repeat 5-10 days later. Do not apply within 7 days of harvest. Use benomyl alone.
Eggplant	Seed rot (RPD915), seed-borne anthracnose, Phomopsis blight (RPD949), and Verticillium wilt (RPD950)	hot water, then thiram or captan	Treat seed just before planting.
	Damping-off (RPD916)	captan	Seedbed or flat spray, 5 gal./100 sq. ft. Repeat at 5- to 7-day intervals.
	Blight (Phomopsis, Alternaria, Cercospora) (RPD949), anthracnose	maneb, zineb, or captan	Start when disease is first evident, *or* when first fruits are half mature. Repeat at 7- to 10-day intervals. *Do not use copper fungicides on eggplant.* May combine with insecticides (Cir. 897).
Lettuce, Endive	Seed rot (RPD915), damping-off (RPD916), gray mold (RPD942)	thiram, Botran, ferbam, zineb	Dust seed lightly with captan 75. Then apply Botran as dust or spray just before or just after seeding. For *field use only.*
	Aster yellows (RPD903), white heart		Use insecticides to control leafhoppers that transmit the mycoplasma. Kill leafhoppers *before* they feed (Cir. 897). Applications needed throughout season. Dust or spray weed borders.
	Mosaics (RPD946)		Use insecticides to control aphids (NHE-47) that transmit the viruses. Kill aphids *before* they feed (Cir. 897). Sow *only* mosaic-indexed seed. Control weeds in and around plant-growing areas (Cir. 907). Keep new and old beds as far apart as possible.

CONDENSED FUNGICIDE RECOMMENDATIONS (continued)

Vegetable	Diseases	Fungicide	Remarks
	Gray mold (RPD942), downy mildew, other fungus leaf spots, white rust	ferbam, maneb, or zineb	Apply at 5- to 7-day intervals in cool, damp weather. Do *not* apply within 10 days of harvest. May combine with insecticides to control aphids, leafhoppers, flea beetles, etc. (Cir. 897).
		Botran	Botrytis control. Do not apply within 14 days of harvest.
	Sclerotinia	Botran or ferbam	
Okra	Seed rot (RPD915), damping-off	thiram	Seed treatment. Apply any time.
Onion, Garlic	Smut (RPD933), seed decay (RPD915), damping-off, seed-borne purple blotch	thiram or captan	Apply to seed any time (RPD933). For *onion sets*, use 1 lb. (100% active) to 20 lb. seed; for *bulb onions*, wet seed with Methocel sticker then treat with 8 lb. thiram 75 or captan 75 to 8 lb. seed. For *pickling and green bunching onions*, same as for bulb onions; but use half dosage. Control seed- and bulb-feeding insects (Cir. 897).
	Blast (RPD931), downy mildew, purple blotch, gray mold blight (RPD942), neck rot (RPD930)	maneb, Difolatan, Bravo 6F, Dyrene, mancozeb, or zineb *plus* spreader-sticker	Apply every 5 to 7 days in moist weather. May combine with insecticides to control thrips, onion maggots, cutworms, etc. (Cir. 897).
	Yellow dwarf, mosaics		Use insecticides to control aphids (NHE-47) that transmit the viruses. Kill aphids *before* they feed (Cir. 897). Keep new and old plantings *as far apart* as possible.
Pea, Lentil	Seed decay (RPD915), damping-off, seed-borne foot rots, Ascochyta and Mycosphaerella blights (RPD945), Fusarium wilts (RPD912), and bacterial blights	Dexon, thiram, captan, or zineb *plus* insecticide	Treat seed any time or buy seed treated with fungicide-insecticide. Sow certified, western-grown seed. Where captan or thiram are used, friction may reduce seeding rate; add graphite (1 oz./bu.).
	Leaf and stem spots or blights (RPD945)	zineb	Apply weekly in rainy weather where diseases have been severe in past.
	Mosaics (RPD947), streaks, stunt, mottle, wilt		Use insecticides to control aphids (NHE-47) and other insects that transmit the viruses. Kill insects *before* they feed (Cir. 897). Also treat field borders.
	Powdery mildew	lime-sulfur dust (4-6 ratio) 30 lb./A.	Do not apply at air temperature above 80° F. or when plants are in flower. Two applications, a week apart, when mildew *first* appears, should be sufficient.
Peanut	Seed rot (RPD915), seedling blights	Botran, thiram, Difolatan, or captan	Treat seed anytime. Do not use treated seed for food, feed, or oil.
Potato, Irish	Seed-piece decays (RPD915), and seed-borne Verticillium wilt (RPD950)	captan, maneb, Polyram, zineb, or mancozeb	Apply as dust or dip to cut and uncut tubers. Follow manufacturer's directions. Tubers should be well corked over. Plant in warm (over 50° F.) soil.
	Blackleg (RPD943)	streptomycin	May combine with treatment for seed-piece decays. Use uncut, B-size, certified seed.
	Early blight (RPD935), late blight (RPD936), and minor leaf spots and blights	maneb, mancozeb, Difolatan, Bravo, Polyram, Dyrene, Du-Ter	Apply at 4- to 10-day intervals. If rainy, shorten interval; if dry, lengthen. For "finish-up" sprays use fixed copper (3 lb. metallic/A.). May combine with insecticides (Cir. 897).
	Common scab (RPD909), and black scurf (*Rhizoctonia*)	PCNB(various formulations)	May help on *mineral* soils. Work into top 4-6 inches of soil at or before planting. Follow manufacturer's directions carefully. Dust seed pieces with difolatan or mancozeb.
	Mosaics, leafroll, mottle, purple-top, yellow dwarf, etc.		Use insecticides to control aphids (NHE-47), leafhoppers (NHE-22), etc., that transmit the viruses. Kill insects *before* they feed (Cir. 897).
Rhubarb	Root and crown rots	fixed copper (3 lb. metallic/A.)	Drench crowns early in spring and after harvest. Plant *only* in *well-drained* soil.
	Leaf and stalk spots, anthracnose	captan, Botran	Avoid applications from 2 weeks before harvest until cutting is completed (greenhouse only). May combine with insecticides (Cir. 897).
	Mosaics, ringspots		Use insecticides to control aphids (NHE-47) that transmit the viruses. Kill aphids *before* they feed (Cir. 897).
Sweet potato	Black rot (RPD953), foot rot (RPD958), Fusarium wilt (RPD954), scurf (RPD957)	Botran thiram (1½ oz./gal.), thiabendazole	Seed dip or bed spray. Dip disease-free roots or sprouts just before planting. Follow manufacturer's directions. Seedbed disinfestation (Cir. 893). Three to 4-year rotation. Strict sanitation. Do not rinse after treatment.
	Storage rots (RPD952)	Botran (as post-harvest dip or in wash water)	Helps reduce transit and market losses caused by Rhizopus soft rot and black rot. Fumigate storage houses with formaldehyde.

CONDENSED FUNGICIDE RECOMMENDATIONS (concluded)

Vegetable	Diseases	Fungicide	Remarks
Tomato, Pepper	Seed decay (RPD915), seed-borne bacterial spot (RPD910), speck and canker (RPD962), early blight (RPD908), Septoria blight, anthracnose, Fusarium wilt (RPD929), leaf mold (RPD941)	hot water, then captan, or thiram	Treat seed, buy treated seed, or certified, disease-free transplants (Cir. 912).
	Bacterial spot (RPD910)	fixed copper-streptomycin mixture	Start when seedlings emerge and apply every 5 days. In *field*, use fixed copper (2-3 lb. metallic/A.) plus maneb or mancozeb (2 lb./A.).
	Damping-off (RPD916) and seedling blights, collar rot (RPD908)	captan, ferbam	Dust or spray in seedbed. Apply as plants emerge so spray runs down stems. Repeat every 4 to 7 days until 10 days before transplanting. Follow the manufacturer's directions.
	Septoria blight (RPD908), early blight, anthracnose, late blight (RPD913) and buckeye rot, gray leaf spot, leaf mold (RPD941)	maneb, mancozeb, Polyram, zineb, Difolatan, Dyrene, Bravo benomyl	Apply every 7 to 10 days *after* first fruit clusters form. Five or more sprays may be necessary, depending on weather. Combine with insecticides to control flea beetles, climbing cutworms, hornworms, fruit flies, etc. (Cir. 897). *Soil surface spray of maneb or Difolatan after last cultivation improves anthracnose control.* Tomato leaf mold and Botrytis control.
	Mosaics (RPD917)		Use insecticides to control aphids (NHE-47) and beetles that transmit the viruses. Kill insects *before* they feed (Cir. 897). Control weeds in and around plant-growing area (Cir. 907). Set out certified, virus-free transplants and start with virus-free seed.
	Blossom-end rot (RPD906)	calcium nitrate (4-6 lb./A.)	Application of 4 or more consecutive sprays in the regular schedule may reduce losses. Start when fruits are the size of grapes. Irrigate to maintain uniform soil moisture.
	Cloudy spot (RPD914)		Use insecticides to control stink bugs that produce cloudy spot by feeding punctures (Cir. 897).
(General diseases that attack most vegetable crops)	Damping-off (RPD916) and seedlings blights; gray mold (RPD942) or Botrytis blight	After planting apply captan, thiram, or zineb (1 T./gal.); ferbam or ziram (2 T./gal.)	Disinfest seedbed soil (Cir. 893), then apply seed treatment (RPD915). Then apply sprays or drenches after planting. Apply *only* if damping-off appears in seedbed and when seedlings need water. (*For crucifers, pepper, peas, beans, tomato, lettuce,* add PCNB to other fungicides to give broad-spectrum control.) Use at least 5 gal. per 1,000 sq. ft. of bed. Repeat at 5- to 7-day intervals when temperature is below 75° F.
	Root knot and other nematodes; Fusarium wilts of various crops (RPD901,904,912,929, 954)	Heat or chemicals may be used. Consult Cir. 893 for names, general precautions, and directions	Disinfest seedbed soil (heat preferred, if available). Follow manufacturer's directions exactly. Fumigants work best in light, loose soils, free of trash, clods, and lumps. Avoid recontamination of treated soil. Best to apply fumigants during the fall that precedes planting. In general, soils must be at least 55° F. at the 6-inch depth with a time lapse of 21-28 days between treating and seeding. Some require gas-tight plastic covers.
	Root and stem or crown rots of various crops (RPD902,911,922,923, 932,948,953)		*Plant resistant varieties when available.*
	Verticillium wilt (RPD950)		

GENERAL SUGGESTIONS ON FUNGICIDE APPLICATION

1. Cover the foliage uniformly. *Ground equipment* — Apply 75 to 125 gallons per acre at approximately 400 pounds per square inch of pressure. Lower volumes and/or pressures may provide adequate coverage, but high-volume, high-pressure applications provide ideal coverage. Make sure the sprayer is functioning properly. Check the nozzles for cleanliness and wear. Boom, height, accuracy of pressure gauge, agitation, and calibration should also be checked. *Aerial application* — Apply recommended amounts of pesticide per acre in 3 to 5 gallons of water. Make sure nozzles are properly aligned and clean, so uniform application is achieved. Cover a swath no wider than is reasonable for the aircraft and boom being used. Spray only those fields which are suitable for aerial application. Avoid fields of irregular shape or topography, particularly if they are bounded by power lines, trees, or other obstructions.

2. Whenever possible spray when the air is still or when wind velocity is not excessive (less than 10 to 12 m.p.h.).

3. Avoid situations where pesticide drift may cause needless problems.

4. When it is compatible with the product label, use a spray adjuvant (surfactant). Some commonly available surfactants are: Colloidal Products X77 (liquid, non-ionic) spreader activator; Colloidal Products Multifilm L. (liquid); Colloidal Products Spray Modifier (liquid, non-ionic) spreader sticker; Millers Nufilm 17 liquid spreader sticker; Millers Nufilm P liquid spreader sticker; Allied Chemical Plyac (liquid) sticker; Rohm and Haas Triton B — 1956 (liquid, non-ionic) spreader sticker; Triton CS7, spreader-binder; and Du Pont Spreader Sticker (liquid) spreader sticker.

RECORD SHEET FOR FUNGICIDE USERS

Date	Vegetable	Chemical	Dosage per acre	Remarks

RPD-915
(Revised 10/77)

VEGETABLE SEED TREATMENT

B.J. Jacobsen and Malcolm C. Shurtleff[1/]

Treatment of vegetable seeds to kill disease-causing organisms (pathogens) borne within or on the seed has repeatedly been shown to prevent plant-disease epidemics (epiphytotics). Protection of the seed or seedling from common soil-inhabiting fungi that cause seed rots and damping-off disease is another benefit of chemical seed treatments. When seed is planted in cold wet soil, or is slow to germinate, seed treatments are often necessary if satisfactory plant stands are to be achieved.

Seed treatments for disease control are of three general types:

1. *Seed disinfection.* The purpose of seed disinfection is to eradicate seed-infecting pathogens from the seed coat, the embryo, or both. Seed disinfection, using hot-water soaks, controls many seed-infecting fungi and bacteria. Recent research has shown 24-hour seed soaks in 0.2 percent thiram to be effective against certain seed-infecting fungi but not bacteria. However, this method of thiram use is not yet cleared by the EPA.

2. *Seed disinfestation.* The purpose of seed disinfestation is to kill pathogens which reside on the surface of the seed.

3. *Seed protection.* The purpose of seed protection is to prevent seed rots and damping-off caused by soil-inhabiting fungi. Fungicides such as thiram, captan, Dexon, dichlone, chloroneb, and PCNB are commonly used as seed protectants. Seed disinfection and disinfestation are commonly followed by a protective seed treatment.

Pretreated seed is available from most vegetable seed supply houses. Be certain to read the label carefully to determine what, if any, treatment has been used. Many growers combine both a fungicide and an insecticide in a seed treatment. Current insecticide recommendations, label precautions, and a compatability chart should be consulted before combining a fungicide and insecticide.

Hot-water treatment. Hot-water soaks will kill most seed-borne fungi and bacteria without killing the seed if properly used. A small sample of each seed lot should be treated and tested for germination before treating the entire lot, because seed lots of poor quality or those more than one year old may not have good germination after hot-water treatment. The water temperature must be controlled very closely since slight reductions in temperature may result in the fungi or bacteria not being killed and slight increases may result in severe seed injury. The following procedures should be strictly followed when using the hot-water treatment.

1. Prewarm seed in a loosely woven cotton bag for 10 minutes in 100° F. water. The treatment bag should be no more than half full and should be gently squeezed during this soak to eliminate all air pockets and to make sure all seeds are wetted.

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2. Place prewarmed seed in a water bath (5 to 10 times the volume of seed to be treated) that will hold the water at the recommended temperatures (Table 1). *Length of treatment time and temperature must be exact!*

3. Immediately after the required treatment time, place the sacks in cold water.

4. Spread seed out to dry. Old screens make excellent drying racks.

5. Apply a protective seed treatment.

Table 1. Water Temperature and Treatment Times for Hot-Water Treatment of Certain Vegetable Seeds

Seed	Water temperature (°F)	Time (minutes)
Broccoli, carrot, cauliflower, Chinese cabbage, collard, cucumber, kale, kohlrabi, rape, rutabaga, turnip	122	20
Brussel sprouts, cabbage, eggplant, spinach, tomatoes	122	25
Mustard, cress, radish	122	15
Pepper	125	30
Lettuce, celery, celeriac	118	30

Note: Other kinds of seed are likely to be injured by this treatment or will not benefit from it.

Seed treatments used in seed disinfestation or in protection may be applied by either the dust method or the slurry method.

Dust method. Place the seed and fungicide in a closed container (Mason jar or drum) and agitate vigorously until the seed is uniformly coated with dust. Best results are obtained when the container is twice the volume of seed treated.

Slurry method. Add enough water to a wettable powder formulation of the selected fungicide to make a sloppy paste. Place the seed in the slurry and stir or swirl until the seeds are thoroughly coated. Dry the seed before planting. (PRECAUTION: Remember that 1 to 3 ounces of seed protectant are sufficient to treat a whole bushel of seed. Do not overdose!)

All seed-treatment chemicals are poisonous to man and animals when taken internally. Some may cause mild to severe skin irritations if allowed to accumulate. Avoid inhaling the dusts or fumes. Do the treating outdoors or in a well-ventilated room. After treatment, or at frequent intervals, wash exposed skin with soap and water.

Carefully mark treated seed and DO NOT USE it for feed, food, or oil purposes. Keep seed-treatment chemicals in a locked cabinet in their original containers. Make sure containers that have been used for treated seed are thoroughly cleaned before reusing. Follow the manufacturer's directions as given on the container regarding concentration, dosage, mixing, and other handling precautions.

Table 2. Seed-Treatment, Materials, and Diseases Controlled for Vegetable Crops

Crop	Diseases controlled	Chemical	Method
Beans[a]	Seed rot, damping-off, Pythium and Rhizoctonia root rots. Streptomycin is partially effective in elimination of surface contamination by the Halo blight organism. Chloroneb can be used for better protection against *Rhizoctonia*.	captan	D,S,PB
		chloroneb	S,PB
		Dexon[b]	D,S
		etridiazol and PCNB[c]	D,S,PB
		maneb	D,PB
		PCNB	D,S
		streptomycin	S
		thiram	D,S
		zineb-captan	D,S
Beet	Seed rot, damping-off, black rot (seedling stage). Application of Solubor may reduce damping-off if boron is deficient.	captan	D,S
		dichlone	D,S
		Dexon	D,S
		thiram	D,S
		zineb-captan	D,S
Cabbage, broccoli, brussel sprouts, cauliflower[a]	Black rot, blackleg, downy mildew, anthracnose, Alternaria leaf spot and blight.	hot water	soak
	Seed rot, damping-off.	captan	D,S,PB
		thiram	D,S
All other crucifers[a]	Black rot, blackleg.	hot water	soak
	Seed rot, damping-off.	captan	D,S,PB
		zineb-captan	D,S
Cantaloupe, cucumber, pumpkin, squash, watermelon	Seed rot, damping-off, *Fusarium*, foot rot of squash, black rot.	captan	D,S,PB
		Dexon[d]	D,S
		thiram	D,S
		zineb-captan	D,S
Other melons		captan	D,S
Carrot[a]	Bacterial blight.	hot water	soak
	Seed rot, damping-off.	thiram	D,S
Collards[a]	Black rot, blackleg.	hot water	soak
	Seed rot, damping-off.	captan	D,S
Corn (pop and sweet)	Seed rot, damping-off.	captan	D,S
		dichlone	D,S
		thiram[e]	D,S
		zineb-captan	D,S
Eggplant	Phomopsis blight, Colletotrichum fruit rot.	hot water	soak
	Seed rot, damping-off.	thiram	D,S

Table 2 (Continued)

Crop	Diseases controlled	Chemical	Method
Endive	Seed rot, damping-off.	thiram	D,S
Garlic (cloves)	White rot.	PCNB	D,S
Kale[a/]	Black rot, blackleg.	hot water	soak
	Seed rot, damping-off.	thiram	D,S
Kohlrabi[a/]	Black rot, blackleg.	hot water	soak
	Seed rot, damping-off.	thiram	D,S
Mustard	Black rot.	hot water	soak
	Seed rot, damping-off,	captan	D,S
	anthracnose.	thiram	D,S
Okra	Seed rot, damping-off.	captan	D
Onion	Seed rot, damping-off.	captan	D
	Seed rot, damping-off, smut.	thiram pelleted with methocel sticker	D,S
Pea[a/]	Seed rot, damping-off, partial control of Ascochyta and Mycosphaerella blights, Aphanomyces root rot.	captan	D,S,PB
		dichlone	D,S
		Dexon	D,S
		etridiazol and PCNB	M,PB
		maneb	D,PB,M
		PCNB	M,D,S
		thiram	D,S
		zineb-captan	D,S
Pepper[a/]	Anthracnose, bacterial spot.	hot water	soak
	Seed rot, damping-off.	captan	D,S
		dichlone	D,S
		thiram	D,S
		zineb-captan	D,S
Potato (seed piece)	*Fusarium*, seed piece decay, scab, seed piece rot.	captan	D
		maneb	D
		Polyram	D
		mancozeb	D,dip
		zineb	D,dip
	Blackleg (bacterial).	streptomycin	D
Radish[a/]	Seed rot, damping-off.	thiram	D,S

Table 2 (Continued)

Crop	Diseases controlled	Chemical	Method
Spinach[e/]	Downy mildew, anthracnose.	hot water	soak
	Seed rot, damping-off.	captan	D,S
		dichlone	D,S
		Dexon	D,S
		thiram	D,S
		zineb-captan	D,S
Sweet potato	Black rot, stem rot, scurf.	Botran	dip
		thiabendazole	dip
		thiram	dip
Swiss chard[a/]	Seed rot, damping-off, leaf spot.	captan	D,S
		dichlone	D,S
		thiram	D,S
		zineb-captan	D,S
Tomato	Bacterial spot, anthracnose, Phoma rot, mosaic.	hot water	soak
	Seed rot, damping-off.	captan	D,S
		dichlone	D,S
		thiram	D,S
		mancozeb	D,S
Turnip[a/]	Black rot, blackleg, anthracnose.	hot water	soak
	Seed rot, damping-off.	captan	D,S
		thiram	D,S

D = Dust; S = Slurry; PB = Planter Box; M = Machine.

a/ Obtain certified disease-free seed or seed grown in the semi-arid areas of the western United States.

b/ Lima and snap only.

c/ Field, kidney, snap, and lima.

d/ Cucumber only.

e/ Sweet only.

Captan is sold as Captan 50-W and 80-W; Captan 75 Seed Protectant; Captan Garden Spray; Captan 80 Spray-Dip; Orthocide 50 and 80 Wettable; Orthocide Fruit and Vegetable Wash; Agway Captan 5D and 7.5D; Orthocide 65 and 75 Seed Protectant; Orthocide Garden Fungicide; Miller's Captan 50W; Patterson's Captan Garden Spray; F & B Captan 7.5 Dust; Chipman Captan Dust; Orthocide 5 Dust, 7.5 Dust, and 10 Dust; etc.

Chloroneb is sold as Demosan.

Dichlone is sold as Dichlone or Phygon.

Etridiazol is sold as Terrazole and Truban.

Maneb is sold as Manzate Maneb Fungicide; Manzate D Maneb; Dithane M-22, M-22 Special; Aceto Maneb; Niagara Maneb; Pratt Lawn and Garden Fungicide; Vancide Maneb 80; Patterson Maneb; Shepard Maneb; Pennwalt Maneb; Chevron Maneb; etc.

Mancozeb is sold as Manzate 200, Dithane M-45, Vancide Maneb Flowable, etc.

PCNB is sold as Terraclor, PCNB, Brassicol, and Fungiclor.

Streptomycin is sold as Agrimycin 17, Stauffer Streptomycin, Phytomycin, Ortho Streptomycin Spray, Streptomycin Antibiotic Spray Powder, Agri-strep, and Ag-Strep.

Thiabendazole is sold as Mertect 340 F.

Thiram is sold as Arasan 50-Red and 75, Roberts Thiram, Chipco Thiram 75, Thiurum 75, Niagara Thiram 65 Wettable Powder, Aceto Thiram-75, Miller's Thiram 65 and 75W, Vancide TM-95 and TM Flowable, etc.

Zineb is sold as Dithane Z-78, Ortho Zineb Wettable, Black Leaf Sheen, Aceto Zineb-75 and -90, Acme Zineb 75 Wettable, Niagara Zineb 75 Wettable, Vancide Zineb 85, Sherwin-Williams Zineb, E-Z-Flo Zineb 75, Pennwalt Zineb W-75, Miller's Zineb Dust, Stauffer Zineb 75-W, Ortho Zineb Dust, Chipman Zineb, etc.

SEED TREATMENTS FOR FIELD CROPS

M.C. Shurtleff and B.J. Jacobsen

Fungicide seed treatment is inexpensive crop insurance against a number of diseases that impair stands, reduce yields, and lower grain quality. Seed treatment is especially valuable during cold, wet weather in protecting germinating seed and young seedlings against seed- and soil-borne fungi that cause seed decay and seeding blights (damping-off). Proper seed treatment controls certain smut fungi of cereals and forage grasses that infect the seed and young seedlings. Fungicide seed treatment is effective in controlling the seed-borne fungi that cause the seedling stage of scab of grasses and small grains, anthracnose, seed-borne root and crown (foot) rots, Helminthosporium stripe and net blotch of barley, spot blotch of small grains, and various seed-borne fungi that cause leaf spots and blotches.

It is usually best to custom-treat at elevators, seed and feed houses, or processing plants *after* the seed is cleaned. Thorough cleaning removes weed seeds, smut "balls" and particles, bits of chaff or straw, and lightweight kernels that may be infected, as well as other undesirable impurities.

Seeds are treated by a fungicide formulated as a dust, wettable powder, flowable, or liquid. The fungicide may be applied to seed as a dust or liquid by using a revolving barrel or oil-drum treater or by adding it to the drill or planter box. Manual mixing with the seed in the drill box immediately before sowing reduces the possibility of treated grain being used for animal feed or human consumption. To ensure thorough mixing, apply half the required amount of fungicide to the half-filled drill box, stir the grain well with a paddle, then add the remaining seed and fungicide and stir again.

Wettable powders are usually applied to seed in a commercial slurry machine. Liquids are commonly applied in various commercial, ready-mix, mist-type, or slurry-type treaters. Fungicides should be applied as close to the time of planting as possible.

The full benefits of seed treatment are not obtained unless combined with (1) planting disease-free seed, (2) rotation with nonrelated crops, (3) clean and deep plowdown of crop debris about every third year or when disease losses have been serious, and (4) planting at the proper time, depth, and spacing.

<u>Before treating, read and follow all the manufacturer's directions on the container label. Do not use treated seed for food, feed, or oil purposes, even after it has been stored for months or years.</u>

Fungicides registered by the federal EPA for seed treatment on field crops are listed in the table. All formulations of a fungicide are registered for the same crops.

Seed Treatment Chemicals

1. <u>Captan</u> (Captan, Orthocide) is registered for use on essentially all field crops. Captan alone does not control smuts of small grains and grasses, but does give control of seed rots or decays and seedling blights (damping-off).

Captan seed protectant materials are sold as Stauffer Captan 25, 75, and 80 Seed Protectant, Captan 4 Flowable Seed Protectant, Captan 25 Planterbox Treater, Captan-Moly Planterbox Treater, and Captan-Moly Seed Protectant; Gallotox Captan FP-700R; Evershield Captan Seed Protectant; Orthocide 4 Flowable Seed Protectant, 80 Concentrate, 90 and 92 Seed Protectant Concentrate, 65 and 75 Seed Protectant; Ortho Soybean Seed Protectant and (MO); Chevron 90 Concentrate; Captan 80 and 95.

Agrosol-S, Granox, and Orthocide Maneb 30-30 Seed Protectant are 30:30 mixtures of captan and maneb. Granox P-F-M is a 30:30 combination of captan and maneb that also contains 1 percent molybdenum.

Stauffer Captan-Thiram 43-43 Seed Protectant contains 43 percent each of captan and thiram.

Turner 4-Way Seed Protectant contains 18.75 percent captan, 18.75 percent maneb, 10 percent PCNB, and 2.5 percent etridiazol.

Other captan-HCB and captan-PCNB mixtures are mentioned below under hexachlorobenzene (HCB) and pentachloronitrobenzene (PCNB).

Captan is also sold in combination with various insecticides to control insects that feed on seed or seedlings. Combination products include:

a. Captan plus diazinon--Ortho Isotox Seed Treater (D), Hopkins Diazinon-Captan-Moly Seed Protectant and Diazinon Captan S.P., Agrox D-C-S and 2-Way, Two Way Seed Treater, Captan-Diazinon 37.5-25 Seed Protectant, Captan Diazinon 37.5-25 Planter Box Seed Protectant, and Agway Protector 2. Agrox Strep, a planter box seed treatment for corn, contains 20 percent captan, 2.5 percent diazinon, and 5 percent streptomycin.

b. Captan plus lindane--Ortho Isotox Seed Treater (F), Captan-Lindane 12.5-25 Planter Box Seed Protectant, and Orthocide Lindane 60-15 Seed Protectant.

c. Captan plus diazinon and lindane--3-Way Fungicide-Insecticide Seed Treatment, Captan-Diazinon-Lindane 33.5-11-16.6 Planter Box Seed Protectant, Agrox 3-Way, Chipman D-L Plus, and Three Way Seed Treatment.

d. Captan plus methoxychlor--Orthocide Methoxychlor 75-3 and 65-10 Seed Protectant, Gallotox Captan Methoxychlor 75-3, Stauffer Methoxychlor 75-2, 75-5, and 65-10 Seed Protectant.

e. Captan plus heptachlor--Captan Heptachlor 10-25 and Planter Box Seed Protectant.

f. Captan plus malathion--Evershield Seed Protectant With Captan And Malathion.

2. Carboxin (Vitavax Fungicide, Vitavax-25 DB Fungicide, Vitavax 200 Fungicide, Vitavax Flowable Fungicide, Vitavax-200 Flowable Fungicide, and Evershield Seed Protectant) is registered for barley, corn, oats, and wheat. Vitavax is the only registered fungicide that systemically controls the loose smut fungi of wheat and barley. It also controls all other smuts of small grains including stinking smut or common bunt, covered and loose smuts of oats, and flag smut as well as certain seed-rotting and seedling blight fungi (such as *Rhizoctonia solani*) and barley stripe.

Vitavax 200 Flowable Fungicide contains 17 percent each of carboxin and thiram while Vitavax 200 Fungicide contains 37.5 percent carboxin and 37.5 percent thiram. These mixtures not only control all smuts of cereals but provide broad-spectrum control of seed rots and seedling blights (damping-off).

3. Dichlone (Phygon, Phygon XL, Phygon Seed Protectant, and Arcadian Diclone) is registered for use on alfalfa, clovers, corn, and sorghums. It is available as a yellow wettable powder and as dusts. It controls only seed rots and seedling blights. Dichlone has been largely replaced by captan, maneb, thiram, HCB, and PCNB.

4. Fenaminosulf (Dexon 70% Wettable Powder Seed and Soil Fungicide and Dexon 70 Seed Protectant) is registered for use on corn and sorghums. It is available as a 70 percent wettable powder and is also sold in combination with PCNB (Terraclor). Dexon is specific for seed rot and damping-off fungi that are water molds (such as *Aphanomyces*, *Phytophthora*, *Pythium*). Dexon wets readily with water to form a slurry suitable for use in any commercial slurry treater or it can be applied as a dry mix.

5. Hexachlorobenzene (or HCB) is registered for use on barley, corn, oats, rye, soybeans, and wheat. It is available as wettable powders, dusts, and liquids for use in slurry, ready-mix, or mist-type treaters and as a dry mix for drill or planter box. HCB is sold as Anticarie, Sanocide Seed Protectant, Chipman No Bunt, Ortho HCB 4 Flowable Seed Protectant, Hexachlorobenzene 40 Seed Protectant, No Bunt 40 Seed Disinfectant, and Smut Go. HCB is effective against seed- and soil-borne smuts (covered smuts of small grains and grasses, loose smut of oats, semiloose or nigra smut of barley), but has little or no activity against most seed decay and damping-off fungi.

HCB is sold in combination with maneb or captan, chiefly for use on small grains, but anti-smut activity may be somewhat less than with pure HCB. The mixtures give good control of seed rots and damping-off.

HCB and captan is sold as Ortho Seed Treatment, HCB 4 Flowable Seed Protectant, Orthocide-HCB, Ortho Wheat Seed Protectant and Flowable, Ortho Drill Box Wheat Seed Protectant, Miller's HCB 4 Flowable, and Morgan HCB Flowable.

HCB and maneb is sold as Granox N-M, Granox Liquid, and Maneb HCB 50-10 Planter Box Seed Protectant.

HCB and captan plus maneb is sold as Res-Q.

6. Mancozeb and Maneb are registered for use on barley, corn, oats, rye, sorghums, soybeans, and wheat. They are available as wettable powders, dusts, or flowables and sold as Manzate Maneb Fungicide and Manzate D Maneb Fungicide; Dithane M-22, M-22 Special, and M-45; Ortho Maneb 80 Fungicide; Agsco DB Yellow and DB Green; and Agrox N-M Drill Box Non Mercurial. These products have fair activity against seed-borne smuts (covered smuts of small grains and forage grasses, loose smut of oats, semiloose or nigra smut of barley), and surface-borne Helminthorsporium stripe of barley, with good activity against seed rots and seedling blights (damping-off).

Maneb is also sold in combination with lindane to control seed- and seedling-eating insects. Combination products include Agsco Be Green, Granol N-M, and Maneb Lindane 50-18.75 Planter Box Seed Protectant.

7. Pentachloronitrobenzene (or PCNB) is registered for use on barley, oats, and wheat. It is available as wettable powders, dusts, or emulsifiable concentrates (liquids) and sold primarily as Terraclor and Terra-Coat LT-2 and Terra-Coat 2-LF Seed Treatment Fungicides. PCNB is used mostly on small grains. It is effective against seed- and soil-borne smut fungi (covered smuts of small grains and forage grasses, loose smut of oats, semiloose or nigra smut of barley) and gives some protection against seed rots and seedling blights (damping-off).

PCNB and etridiazol (Terrazole) mixtures include Olin Terraclor Super-X and Terra-Coat L-21, L-205, and SD-20 Seed Treatment Fungicides.

PCNB-captan mixtures are sold as Stauffer Captan-Terraclor 10-10 and 30-30 Seed Protectants; Orthocide PCNB 10-20 Dust; Ortho Soil Treater X and 3X; Terracap; PCNB-Captan 25-25 Wettable Powder; Terraclor 20-Captan 10 Dust, Terraclor 50-Captan 25 Wettable Powder, and PCNB-Captan 25-25 Wettable Powder.

A PCNB-Polyram mixture is sold as a 10:10 dust.

8. Polyram (or metiram) is registered for use on barley, oats, sorghums, and wheat. It is available as wettable powders and dusts. Polyram has good activity against most seed-borne smuts (covered smuts of small grains and forage grasses, loose smut of oats, semiloose or nigra smut of barley), seed rots, and seedling blights (damping-off) but may be somewhat erratic in action. Polyram is sold as Niagara Polyram 80WP, 7 Dust and Seed Treater; Polyram Wettable Powder; Agway Polyram 7D and Polyram 80W; Polyram Seed Treater; Naco Polyram Dusts; Polyram 80 Wettable Powder, and Polyram 7 Dust.

9. TCMTB is registered for use on barley, corn, oats, soybeans, and wheat. It is sold as Busan 30 and 72, Cover-Up L, Thiogem, and Protector-3L. TCMTB has activity against seed rots and seedling blights, all covered smuts, loose smut of oats, and semiloose or nigra smut of barley. It may be phytotoxic if improperly applied.

10. Thiram is registered for use on essentially all field crops except oats. It is available as wettable powders, dusts, and flowables. Thiram is sold primarily as Arasan 50-Red Thiram Seed Protectant, 50-Red ND Thiram Seed Protectant, 42-S Thiram Fungicide and Repellent, 70-S Seed Protectant, and 75 Thiram Seed Protectant; Evershield Seed Protectant; Chipco Thiram 75; Thiram 75; Tinasad; Rhodia Sup'r-Wet Thiram; Metasol Thiram 75%; Occidental Thiram; Fungisan; and Pearson's Moly-Stand Soybean Seed Protectant. Thiram has activity against most seed-borne smuts (all covered smuts, semiloose or nigra smut of barley), Helminthosporium stripe of barley, seed rots, and seedling blights (damping-off).

11. Zineb is registered in combination with captan for use on alfalfa, barley, clovers, corn, forage grasses, oats, sorghums, soybeans, and wheat. It is available as wettable powders and dusts, and sold primarily as Zineb, Dithane Z-78, Black Leaf Sheen, Thiogreen Dust Fungicide, Naco Dithane 6 and 10 Dust, and Staples Dithane Seed Treating Dust. Zineb is formulated as a 21 percent WP in combination with 22 percent captan.

(NOTE: Seed treatment is not normally suggested for alfalfa and clovers. Some midwestern states recommend treating soybean seed with a fungicide. Sowing treated seed usually increases stands for these crops but does not usually increase yields, especially where seed germinating 80 to 85 percent or more in a cold test is planted.)

Seed Treatment Fungicides Registered for Use on Field Crops[a]

Fungicide	Alfalfa[b]	Barley	Broomcorn	Clovers[b]	Corn, field	Grasses, forage	Oats	Rye	Sorghums	Soybeans[b]	Wheat
Captan (Captan, Orthocide)[c]	X	X		X	X	X	X	X	X	X	X
Captan + Maneb (Agrosol-S, Granox, etc.). .		X			X		X	X		X	X
Captan + Thiram		X			X				X	X	X
Captan + Zineb.	X	X		X	X	X	X		X	X	X
Captan + HCB.		X					X				X
Captan + HCB + Maneb (Res-Q).		X			X		X	X		X	X
Captan + PCNB (Captan-Terraclor, etc.). . .									X	X	X
Carboxin (Vitavax)[d]		X			X		X				X
Carboxin + Thiram (Vitavax 200)[d]		X			X		X				X
Dichlone (Phygon)	X			X	X				X		
Fenaminosulf (Dexon).					X				X		
Hexachlorobenzene (HCB)		X			X		X	X		X	X
HCB + Maneb (Granox N-M, Granox Liquid) . .		X			X		X	X		X	X
Mancozeb, Maneb		X			X		X	X	X	X	X
PCNB (Terraclor, Terracoat LT-2, 2-LF) . .		X					X				X
PCNB + Etridiazol (Terraclor Super-X, Terra-Coat L-21, L-205, and SD-20) . . .		X			X				X	X	X
Polyram, Metiram.		X					X		X		X
TCMTB (Busan, Cover-Up, Thiogem, etc.). . .		X			X		X			X	X
Thiram (Arasan, Panoram, Tinasad, etc.) . .	X	X		X	X	X		X	X	X	X
Thiram + Maneb.					X						

[a]Use all seed treatment chemicals strictly according to label directions.
[b]Seed treatment is not normally suggested for alfalfa, clover, and soybean seed.
[c]For representative trade names of fungicides and combinations see text.
[d]Controls loose smut of wheat and barley.

SPRAY CHART FOR SOME IMPORTANT DISEASES OF WOODY ORNAMENTALS IN ILLINOIS

M.C. Shurtleff, B.J. Jacobsen

Plant and disease	Suggested fungicides	Rate[1] (lb./100 gal. unless specified otherwise)	Application and remarks
ALDER			
Powdery mildew	benomyl, 50% WP[2]	½	Spray 2 or more times, 7 to 10 days apart, starting when disease first appears.
	sulfur, 95% WP	2-3	
ALMOND - See Cherry			
AMELANCHIER (Shadbush, Serviceberry, Juneberry)			
Cedar rusts	ferbam, 76% WP	2	Spray 3 times at 10-day intervals, starting when new growth appears in the spring.
	thiram, 65-75% WP	1½-2	
	zineb, 75% WP	1½-2	
	mancozeb, 80% WP	1½-2	
Powdery mildew	Karathane, 22.5% WP	½	Spray when disease first appears or as leaves start to expand. Repeat 2 or 3 times 10 days apart.
	benomyl, 50% WP	½-1	
	sulfur, 95% WP	2-3	
APPLE - See Crabapple			
ARBORVITAE			
Phomopsis needle and twig blight	benomyl, 50% WP	1	Only new growth is susceptible. Spray whenever new growth appears and after shearing or wet weather. Spray at budbreak and then repeat at 10- to 14-day intervals until new growth has matured.
ASH			
Anthracnose, Fungus leaf spots	copper[3]	See label	Apply when buds begin to open. Repeat 10 to 14 days later. Zineb also controls rust.
	zineb, 75% WP	1½-2	
	captan, 50% WP	2	
	benomyl, 50% WP	½-1	
AZALEA - See Rhododendron			

(Footnotes at end of table.)

Plant and disease	Suggested fungicides	Rate[1] (lb./100 gal. unless specified otherwise)	Application and remarks
BARBERRY Bacterial leaf spot and twig blight, Fungus leaf spot, blotch, and anthracnose	copper	See label	Spray 2 or 3 times, 10 days apart, beginning when new leaves appear in spring.
BASSWOOD - See Linden			
BEECH Fungus leaf spot	copper	See label	If severe, spray twice, 10 days apart, starting as the leaves begin to unfold.
Powdery mildew	Karathane, 22.5% WP benomyl, 50% WP sulfur, 95% WP	½ ½-1 2-3	If severe, spray twice, 10 days apart, starting when mildew is first seen.
BIRCH Leaf blister	copper liquid lime-sulfur	See label 2 gal.	Spray once before buds swell in early spring.
Anthracnose	copper zineb, 75% WP	See label 1½-2	Spray twice, 10 to 14 days apart, starting at budbreak.
Rust	zineb, 75% WP mancozeb, 80% WP	2 1½-2	Spray several times at 10-day intervals. Start about a week before rust normally appears.
BITTERSWEET Powdery mildew	benomyl, 50% WP Karathane, 22.5% WP	½-1 ½	If severe, spray 2 or 3 times at 10-day intervals, starting when mildew first appears.
Fungus leaf spots	copper	See label	Spray twice, 10 days apart, starting as leaves unfold.
BOXELDER - See Maple			
BOXWOOD Canker, Fungus leaf blights or spots	copper liquid lime-sulfur	See label 2 gal.	Apply 4 times: while dormant after old leaves have been cleaned up and before new growth starts, 10 to 14 days later, when growth is half complete, and in autumn when fall growth has ceased.

Plant and disease	Suggested fungicides	Rate[1] (lb./100 gal. unless specified otherwise)	Application and remarks
Phytophthora root rot	etridiazol (Truban) fenaminosulf (Dexon)	See label See label	Apply as drench around plants to saturate the soil. Repeat at 2- to 12-week intervals in spring and autumn.
BUCKEYE - See Horsechestnut			
BUSH HONEYSUCKLE Fungus leaf spot	copper	See label	Spray twice, 10 days apart, starting as the leaves unfold.
Powdery mildew	benomyl, 50% WP Karathane, 22.5% WP	½-1 ½-1	Spray 2 or 3 times, 10 days apart. Start when mildew first appears.
BUTTERNUT - See Walnut			
BUTTONBUSH Powdery mildew	benomyl, 50% WP sulfur, 95% WP Karathane, 22.5% WP	½-1 2-3 ½	Make several weekly sprays. Start when disease first appears.
BUTTONWOOD - See Sycamore			
CATALPA Powdery mildew	piperalin benomyl, 50% WP sulfur, 95% WP	¼ ½-1 2-3	Spray when disease first appears. Repeat 10 to 14 days later.
Fungus leaf spots	copper	See label	If severe, spray when leaves are unfolding, when leaves reach full size, and 2 weeks later.
CHERRY, PEACH, PLUM, ALMOND, MAYDAY-TREE, CHERRY PLUM, CHERRY-LAUREL Black knot	dodine, 65% WP zineb, 75% WP ferbam, 76% WP benomyl, 50% WP mancozeb, 80% WP	½-1 1½-2 2 ½-1 1½-2	Spray as buds begin to swell. Repeat at pink bud, at full bloom, and at 10 and 20 days later.
Brown rot, blossom and twig blight	benomyl, 50% WP sulfur, 95% WP captan, 50% WP captafol 4F	½-1 5-10 2 2	Spray when first blossoms open, during full bloom, and again at petal-fall. Thorough coverage is required.

Plant and disease	Suggested fungicides	Rate[1] (lb./100 gal. unless specified otherwise)	Application and remarks
Leaf blister or curl, Plum pockets, Witches'-broom	captan, 50% WP liquid lime-sulfur ferbam, 76% WP dodine, 65% WP copper	2 2 gal. 2 ½-1 See label	Spray once in late fall or just before buds swell in early spring.
Coccomyces leaf spot, blight, or shot-hole	benomyl, 50% WP dodine, 65% WP captan, 50% WP Acti-dione PM	½-1 ½-1 2 See label	Spray 3 or 4 times, 2 weeks apart. Start as buds are opening. Use Acti-dione only on nonbearing trees.
Perennial canker	ferbam, 76% WP benomyl, 50% WP	2 ½-1	Delay pruning until buds open in spring. Spray just after pruning.
Powdery mildew	benomyl, 50% WP Karathane, 22.5% WP sulfur, 95% WP Acti-dione PM	½-1 ½ 2-3 See label	Spray when mildew first appears. Repeat once or twice at 7- to 10-day intervals. Use Acti-dione only on nonbearing trees.
Rust	ferbam, 76% WP zineb, 75% WP sulfur, 95% WP	2 1½-2 4-6	Spray several times, about 10 days apart. Start about 2 weeks after petal-fall.
Scab, Shot-hole, Fungus leaf spots	benomyl, 50% WP sulfur, 95% WP captan, 50% WP ferbam, 76% WP zineb, 75% WP	½-1 5-10 2 2 1½-2	Spray about 3 times, 10 to 14 days apart, starting at petal-fall.
CONIFERS - See Pine			
COTONEASTER Fire blight	streptomycin formulations bordeaux mixture	See label 2-6-100	Apply during bloom at 5- to 7-day intervals. Do *not* use streptomycin on *C. racemifolia*; you may substitute bordeaux if temperature is above 65° F.
Scab	benomyl, 50% WP dodine, 65% WP	½-1 ½-1	Apply in spring as buds start to swell and repeat 2 to 3 weeks later.
Fungus leaf spots	benomyl, 50% WP maneb, 80% WP zineb, 75% WP	½-1 1½-2 1½-2	Spray several times 10 to 14 days apart. Commence at budbreak.

Plant and disease	Suggested fungicides	Rate[1] (lb./100 gal. unless specified otherwise)	Application and remarks
CRABAPPLE, APPLE, PEAR			
Cedar rusts (apple, hawthorn, quince)	ferbam, 76% WP	2	Spray as new growth appears and flower buds start to open. Repeat 3 or 4 more times at 10-day intervals.
	maneb, 80% WP	1½-2	
	mancozeb, 80% WP	1½-2	
	thiram, 65-75% WP	1½-2	
	zineb, 75% WP	1½-2	
	Polyram, 80% WP	1½-2	
Scab, Fungus leaf spots and fruit rots, Sooty blotch	zineb, 75% WP	1½-2	Spray as soon as growth appears. Repeat 4 more times, 7 to 10 days apart. Thorough coverage of new growth is essential. Captafol (Difolatan 4F) is applied as a single application before bloom for control of primary apple scab. See label.
	benomyl, 50% WP	1	
	dodine, 65% WP	½-1	
	captan, 50% WP	2	
	maneb, 80% WP	1½-2	
	mancozeb, 80% WP	1½-2	
	Polyram, 80% WP	1½-2	
	folpet, 50% WP	1½-2	
	Dikar, 80% WP	2	
	captafol, 4F	1½-2 pts.	
Fire blight	streptomycin formulations	See label	Spray when 20 to 25 percent of blossoms are open and repeat at 5- to 7-day intervals during bloom. Then apply weekly for 5 or 6 weeks. Best control when spraying at night.
	copper	See label	
Powdery mildew	benomyl, 50% WP	½-1	Spray when disease first appears or as leaves start to expand. Repeat 2 or 3 times, 10 days apart.
	sulfur, 95% WP	6-8	
	Karathane, 22.5% WP	½	
CURRANT, ALPINE			
Anthracnose, Fungus leaf spots	benomyl, 50% WP	½-1	Spray 2 or 3 times, 10 to 14 days apart. Start at leaf emergence or when leaves are nearly expanded.
	ferbam, 76% WP	2	
	maneb, 80% WP	1½-2	
	mancozeb, 80% WP	1½-2	
	zineb, 75% WP	1½-2	
DOGWOOD			
Fungus leaf spots, Leaf blotch, Anthracnose, Spot anthracnose, Flower and leaf blights	benomyl, 50% WP	1	Spray at budbreak and just before flower bracts are fully expanded. Repeat 2 or 3 more times about 2 weeks apart.
	maneb, 80% WP	1½-2	
	mancozeb, 80% WP	1½-2	
	zineb, 75% WP	1½-2	
	captan, 50% WP	2	

Plant and disease	Suggested fungicides	Rate[1] (lb./100 gal. unless specified otherwise)	Application and remarks
Powdery mildew	benomyl, 50% WP sulfur, 95% WP Karathane, 22.5% WP	½-1 2-3 ½-1	Spray when mildew first appears. Repeat 7 to 10 days later if needed.
ELM Anthracnose, Black leaf spot, other fungus leaf spots, Twig blight	sulfur, 95% WP copper zineb, 75% WP mancozeb, 80% WP ferbam, 76% WP	2-3 See label 1½-2 1½-2 2	Spray 3 times, 10 to 14 days apart. Start when the leaf buds break open.
Dutch elm disease	metham or SMDC (Vapam Soil Fumigant)	See label	Soil treatment when disease first appears to prevent transmission by root grafts. Follow label directions.
	Methoxychlor	See label	Apply just before budbreak to prevent inoculation by elm bark beetles.
	Arbotect 20-S[4] *or* MBC-phosphate-carbendazin[4] (formerly Lignasan BLP, now sold as Hopkins Correx Fungicide, Agway Elmosan, Pratt Elm Tree Noculate, Arboral Fungicide, and Lily/Miller Ulmasan)	See label See label	For *protective* treatment. Should be injected into elms more than 5 inches in diameter by a trained arborist *before* elms contract the disease or when trees are newly infected, and have less than 5 percent crown damage.
EUONYMUS Fungus leaf spots, Anthracnose, scab	benomyl, 50% WP maneb, 80% WP mancozeb, 80% WP zineb, 75% WP copper	½-1 1½-2 1½-2 1½-2 See label	Apply at budbreak or at first sign of disease. Spray 2 or 3 times at 7- to 10-day intervals.
Powdery mildew	Acti-dione PM Karathane, 22.5% WP sulfur, 95% WP benomyl, 50% WP	See label ½-1 4-5 ½-1	Apply at first evidence of disease. Repeat at 7- to 10-day intervals.
EVERGREENS - See Fir, Juniper, Pine, Yew			

Plant and disease	Suggested fungicides	Rate[1] (lb./100 gal. unless specified otherwise)	Application and remarks
FIR			
Needle and twig blight, leaf casts	copper	See label	Spray 2 or 3 times, 15 to 30 days apart, starting when new needles are half grown.
Rusts	sulfur, 95% WP	3-5	Spray 2 or 3 times, 7 to 10 days apart. Start a week before rust usually appears.
FIRETHORN - See Pyracantha			
FORSYTHIA			
Fungus leaf spots	mancozeb, 80% WP	1½-2	Apply at budbreak and repeat at 7- to 10-day intervals as needed to keep foliage protected in damp weather.
	maneb, 80% WP	1½-2	
	zineb, 75% WP	1½-2	
	copper	See label	
HAWTHORN, RED HAW			
Leaf blight, scab, other fungus leaf spots	Polyram, 80% WP	1½-2	Apply 3 or 4 sprays at 7- to 10-day intervals, starting as new growth appears. Extend the schedule during rainy seasons.
	captan, 50% WP	2	
	benomyl, 50% WP	1	
	maneb, 80% WP	1½-2	
	mancozeb, 80% WP	1½-2	
	zineb, 75% WP	1½-2	
	dodine, 65% WP	½	
	Acti-dione PM	See label	
Cedar rusts	ferbam, 76% WP	2	Spray as new growth appears and flower buds start to open. Repeat 3 or 4 times at 7- to 10-day intervals.
	thiram, 65-75% WP	1½-2	
	zineb, 75% WP	1½-2	
	maneb, 80% WP	1½-2	
	mancozeb, 80% WP	1½-2	
Fire blight	streptomycin formulations	See label	Spray when 20 to 25 percent of blossoms are open and at 5- to 7-day intervals during bloom. Do not use streptomycin on *C. mollis*.
Powdery mildew	Karathane, 22.5% WP	½-1	Spray twice, 10 days apart, starting when mildew first appears.
	benomyl, 50% WP	½-1	
	sulfur, 95% WP	4-5	
HICKORY			
Anthracnose, Fungus leaf spot or blotch, scab, spot anthracnose	benomyl, 50% WP	½-1	Spray 3 or 4 times, 7 to 10 days apart, starting when the buds break open.
	zineb, 75% WP	1½-2	
	mancozeb, 80% WP	1½-2	
	maneb, 80% WP	1½-2	

Plant and disease	Suggested fungicides	Rate[1] (lb./100 gal. unless specified otherwise)	Application and remarks
HOLLY Fungus leaf spots, Tar spot, Anthracnose, Spot anthracnose	benomyl, 50% WP zineb, 75% WP maneb, 80% WP mancozeb, 80% WP copper	½-1 1½-2 1½-2 1½-2 See label	Apply 3 or 4 sprays at 10- to 14-day intervals. Start as leaves begin to unfold. Some holly species and cultivars are sensitive to copper materials in cold, damp weather.
Leaf and twig blight, algae	copper zineb, 75% WP	See label 1½-2	Spray 3 or 4 times, 10 days apart. Start with the first autumn rains.
Powdery mildew	sulfur, 95% WP benomyl, 50% WP Karathane, 22.5% WP	4-5 ½-1 ½-1	Apply at first disease appearance. Repeat at 7-day intervals as needed.
HONEYSUCKLE Herpobasidium leaf blight	copper mancozeb, 80% WP maneb, 80% WP	See label 1½-2 1½-2	Apply several sprays 7 to 10 days apart. Start when new growth appears. Only young leaves are infected.
Powdery mildew	benomyl, 50% WP sulfur, 95% WP Acti-dione PM Karathane, 22.5% WP	½-1 4-5 See label ½-1	Spray 2 or more times at weekly intervals. Start when disease first appears.
HORSECHESTNUT, BUCKEYE Leaf blotch, Fungus leaf spot or blotch, Anthracnose, Spot anthracnose	benomyl, 50% WP zineb, 75% WP mancozeb, 80% WP maneb, 80% WP dodine, 65% WP	½-1 1½-2 1½-2 1½-2 1-2	Spray 3 or 4 times, 10 to 14 days apart, starting as the buds begin to open. Thorough coverage is required for control.
HYDRANGEA Fungus leaf spots, Rust	benomyl, 50% WP zineb, 75% WP ferbam, 76% WP chlorothalonil, 75% WP	1 1½-2 2 1½-2	Spray 3 times, 7 to 10 days apart. Start when new growth appears. Benomyl will not control rust.
Botrytis leaf blight	benomyl, 50% WP Botran, 50% WP chlorothalonil, 75% WP	½-1 1-1½ 1½-2	Spray when first symptoms appear. Repeat twice weekly during rainy periods.

Plant and disease	Suggested fungicides	Rate[1] (lb./100 gal. unless specified otherwise)	Application and remarks
Powdery mildew	benomyl, 50% WP Karathane, 22.5% WP sulfur, 95% WP	½-1 ½ 2-3	Spray several times, 7 to 10 days apart. Start when disease first appears.
JUNEBERRY - See Amelanchier			
JUNIPER, REDCEDAR Rusts	zineb, 75% WP Acti-dione ferbam, 76% WP Polyram, 80% WP	1½-2 See label 2 1½-2	Spray susceptible junipers 4 times, 10 to 20 days apart, starting about midsummer. Acti-dione is applied in spring before galls become orange and jellylike.
Phomopsis canker or twig blight	benomyl, 50% WP	1	Spray several times at 2-week intervals. Keep new growth protected. See Arborvitae.
Cercospora needle blight	copper	See label	Spray when disease first appears or after June 1; repeat at 7- to 10-day intervals.
KALANCHOË Powdery mildew	benomyl, 50% WP	½-1	Spray several times at 10-day intervals. Start when disease first appears.
LILAC Powdery mildew	benomyl, 50% WP sulfur, 95% WP Karathane, 22.5% WP	½-1 4-6 ½-1	Spray several times at 7- to 10-day intervals. Start when disease first appears. If using benomyl, apply at 3-week intervals.
Bacterial and Phytophthora blights	copper	See label	Spray 2 or 3 times at 7- to 10-day intervals. Start when new growth appears in spring.
LINDEN, BASSWOOD Anthracnose, Fungus leaf spots, Leaf blight, Spot anthracnose	copper benomyl, 50% WP	See label ½-1	Spray just after budbreak and again 10 and 20 days later.

Plant and disease	Suggested fungicides	Rate[1] (lb./100 gal. unless specified otherwise)	Application and remarks
Powdery mildew	benomyl, 50% WP sulfur, 95% WP	½-1 4-6	Spray when mildew first appears. Repeat 10 days later.
MAGNOLIA Powdery mildew	benomyl, 50% WP Acti-dione PM Karathane, 22.5% WP	½-1 See label ½-1	Spray 2 or 3 times, 7 to 10 days apart. Start when disease first appears.
Fungus leaf spot, Leaf blight	copper *plus* benomyl, 50% WP	See label ½-1	Spray twice, 10 days apart. Start as buds break open.
MAPLE, BOXELDER Anthracnose, Fungus leaf spots, Leaf blight or blotch, leaf scab, Tar spot, leaf blister	copper zineb, 75% WP mancozeb, 80% WP maneb, 80% WP benomyl, 50% WP	See label 1½-2 1½-2 1½-2 1	Spray 3 or 4 times, 10 to 14 days apart, starting as the buds *begin* to open.
MAYDAY-TREE - See Cherry			
MOUNTAIN-ASH Leaf blight, scab, Fungus leaf spots	benomyl, 50% WP mancozeb, 80% WP zineb, 75% WP	½-1 1½-2 1½-2	Spray 2 to 4 times, 14 days apart, starting as the leaf buds open.
Rusts	zineb, 75% WP mancozeb, 80% WP	1½-2 1½-2	Apply 4 or 5 sprays, 10 days apart, starting as the flower buds begin to open.
Fire blight	streptomycin formulations copper	See label See label	Spray when 20 to 25 percent of blossoms are open and again at full bloom.
MULBERRY Bacterial blight or leaf spot, Fungus leaf spot, False mildew	bordeaux mixture copper	5-5-100 See label	Apply at budbreak and repeat at 7-day intervals during moist periods. If severe, spray twice, 10 days apart, starting as the leaves unfold.
Powdery mildew	benomyl, 50% WP Karathane, 22.5% WP	½-1 ½-1	Spray twice, 10 days apart. Start when mildew is first seen.

Plant and disease	Suggested fungicides	Rate[1] (lb./100 gal. unless specified otherwise)	Application and remarks
OAK			
Anthracnose,	copper	See label	Spray 3 times: just before buds open, when leaves are half grown, and 10 to 14 days later.
Fungus leaf spots and blights,	zineb, 75% WP	1½-2	
	captan, 50% WP	4	
Spot anthracnose,	benomyl, 50% WP	1	
Leaf blotch,	dodine, 65% WP	1	
Leaf blister	mancozeb, 80% WP	1½-2	
	maneb, 80% WP	1½-2	
Oak wilt	2,4,5-T[5]	4 lb. a.i. /gal. oil	Apply to deep girdle and axe cuts in roots to run-off before 50 percent wilt of tree develops. Treatment kills infected trees; prevents spread to healthy oaks.
	metham or SMDC (Vapam Soil Fumigant)	See label	Soil treatment when disease first appears to prevent transmission to nearby healthy oaks by root grafts. Follow label directions.
PEACH - See Cherry			
PECAN			
Scab, fungus leaf spots,	benomyl, 50% WP	½-1	Apply 4 to 6 sprays, 10 to 14 days apart. Start when buds begin to open. Thorough coverage is required. Follow manufacturer's directions.
	zineb, 75% WP	1½-2	
Leaf blotch and scorch,	maneb, 80% WP	1½-2	
	mancozeb, 80% WP	1½-2	
Spot anthracnose,	dodine, 65% WP	½-1	
Anthracnose	copper	See label	
	Polyram, 80% WP	2	
	Du-Ter, 47.5% WP	½	
Powdery mildew	benomyl, 50% WP	½-1	Spray when mildew is first seen. Repeat at 10- to 14-day intervals.
	Du-Ter, 47.5% WP	¼-½	
	Karathane, 22.5% WP	½-1	
PHOTINIA			
Powdery mildew	benomyl, 50% WP	½-1	Spray several times at 10- to 14-day intervals. Start when new leaf growth or disease first appears.
	sulfur, 95% WP	4-6	

Plant and disease	Suggested fungicides	Rate[1] (lb./100 gal. unless specified otherwise)	Application and remarks
PINE Dothistroma needle blight	copper	See label	Spray twice: when new needles are just emerging and again when new needles are fully expanded.
Scirrhia brown spot needle blight	copper mancozeb, 80% WP maneb, 80% WP chlorothalonil	See label 1½-2 1½-2 See label	Spray once or twice, 30 days apart, starting when new needles are half grown. If rainy, spray at 2-week intervals.
Lophodermium needle cast or blight	mancozeb, 80% WP maneb, 80% WP chlorothalonil copper	1½-2 1½-2 See label See label	Spray 4 times, 2 to 3 weeks apart, starting about midsummer when the new needles are full grown.
Diplodia tip blight	copper benomyl, 50% WP	See label 1	Spray 3 times, 10 to 14 days apart. Start as new growth appears.
Scleroderris canker	chlorothalonil, 6F	1½ qts.	Spray as new growth appears in spring. Repeat at 2- to 3-week intervals until early July, then monthly until early September.
Annosus root and butt rot	borax, 97% (dry, powdered)	1 lb./50 sq. ft. of stump surface	Cover fresh-cut stump surface immediately after felling tree. Sprinkle liberally and evenly.
Cylindrocladium blight	benomyl, 50% WP ferbam, 76% WP	½ 2	Apply as a soil drench to seedling beds at 2- to 4-week intervals.
Damping-off	etridiazol (Truban)	See label	Drench around plants in nursery beds at 2- to 4-week intervals.
	PCNB (Terraclor)	See label	Drench nursery beds of southern pines prior to seeding. Follow with ½ inch of water.
PLANETREE - See Sycamore			
PLUM - See Cherry			

Plant and disease	Suggested fungicides	Rate[1] (lb./100 gal. unless specified otherwise)	Application and remarks
POPLAR			
Leaf rusts	zineb, 80% WP	2	Spray about a week before rust is expected and again 10 to 14 days later.
	mancozeb, 80% WP	2	
	maneb, 80% WP	2	
Yellow leaf blister	zineb, 75% WP	2	Apply several weekly sprays when spots first appear on the lower leaves.
	mancozeb, 80% WP	2	
	maneb, 80% WP	2	
Powdery mildew	sulfur, 95% WP	4½-5½	Apply at first sign of disease. Repeat 2 or 3 times at 5- to 10-day intervals.
PRIVET			
Anthracnose, Fungus leaf spot, Twig blight	ferbam, 76% WP	2	Spray several times at 10-day intervals, starting in midspring.
	benomyl, 50% WP	1	
Powdery mildew	benomyl, 50% WP	½-1	Spray twice, 10 days apart. Start when mildew is first seen.
	Karathane, 22.5% WP	½-1	
	sulfur, 95% WP	4-6	
PYRACANTHA (Firethorn)			
Fire blight	streptomycin formulations	See label	Spray when 20 to 25 percent of blossoms are open and repeat at 5- to 7-day intervals during bloom.
	copper	See label	
Scab	benomyl, 50% WP	1	Spray 4 times: just before blossoms open, at petal-fall, 2 and 4 weeks later.
	folpet, 50% WP	2	
	dodine, 65% WP	½-1	
QUINCE			
Fire blight	bordeaux mixture	2-6-100	Spray when 20 to 25 percent of blossoms are open; repeat when 75 percent are open. Do not use streptomycin on quince.
Rust, Scab, Fungus leaf spots	maneb, 80% WP	1½-2	Apply several sprays at 10-day intervals starting at budbreak.
	mancozeb, 80% WP	1½-2	
	zineb, 75% WP	1½-2	
	ferbam, 76% WP	2	
REDBUD			
Cercospora and other fungus leaf spots	copper	See label	If serious, apply at budbreak and repeat several times at 10-day intervals during the spring rainy period.
	maneb, 80% WP	1½-2	
	mancozeb, 80% WP	1½-2	

Plant and disease	Suggested fungicides	Rate[1] (lb./100 gal. unless specified otherwise)	Application and remarks
REDCEDAR - See Juniper			
RED HAW - See Hawthorn			
RHODODENDRON, AZALEA			
Ovulinia petal or flower blight of azalea	benomyl, 50% WP zineb, 75% WP mancozeb, 80% WP thiram, 65-75% WP	1 1 1 1	Spray as flowers open. Then apply benomyl at 5-day intervals, or zineb, mancozeb, or thiram 3 times weekly during the bloom period.
Powdery mildew	benomyl, 50% WP sulfur, 95% WP Karathane, 22.5% WP	½-1 3-6 ½-1	Spray several times at 7- to 10-day intervals. Start when disease first appears.
Fungus leaf spots, Rusts	zineb, 75% WP maneb, 80% WP mancozeb, 80% WP benomyl, 50% WP ferbam, 76% WP chlorothalonil, 75% WP	1½-2 1½-2 1½-2 ½-1 2 1½-2	Spray several times at 10-day intervals. Start when new growth appears or right after bloom. Zineb, maneb, mancozeb, ferbam, and chlorothalonil are effective against rusts; benomyl is not.
Leaf, flower, and stem gall	zineb, 75% WP ferbam, 76% WP	1½ 2	Spray just before budbreak and continue as for fungus leaf spots.
Bud and twig blight, Dieback	copper	See label	Make 3 sprays, 7 to 10 days apart, starting at budbreak.
Root and crown rot or wilt (*Phytophthora cinnamomi* and other fungi)	etridiazol (Truban) fenaminosulf (Dexon)	See label See label	Apply as a drench around plants to saturate the soil. Repeat at 2- to 12-week intervals in spring and autumn. Follow label directions.
Cutting rot	benomyl, 50% WP	See remarks	Mix 1 part benomyl with 39 parts of root-inducing hormone powder by weight. Treat cutting ends with mixture before "sticking" in rooting medium. Then drench soil as for root and crown rot or wilt.
	etridiazol (Truban)	See label	Apply as for root and crown rot or wilt.

Plant and disease	Suggested fungicides	Rate[1] (lb./100 gal. unless specified otherwise)	Application and remarks
ROSE			
Botrytis blight	benomyl, 50% WP	½	Apply to flowers at 7- to 10-day intervals in moist weather
	Botran, 50% WP	See label	
	zineb, 75% WP	1	
Black spot, Cane blight and cankers, Spot anthracnose, Anthracnose, Fungus leaf spots	chlorothalonil	See label	Spray at 7- to 10-day intervals starting when new growth appears. Shorten spray interval to 5 or 7 days in rainy weather. Maneb, mancozeb, Polyram, and chlorothalonil also control rusts.
	folpet, 50% WP	1½-2	
	maneb, 80% WP	1½-2	
	mancozeb, 80% WP	1½-2	
	Polyram, 80% WP	1½-2	
	benomyl, 50% WP	1	
	zineb, 75% WP	1½-2	
Powdery mildew	benomyl, 50% WP	1	Spray at 7- to 10-day intervals, starting when new growth appears. Thorough coverage is required.
	Karathane, 22.5% WP	½-1	
	sulfur, 95% WP	2-3	
	parinol	See label	
	piperalin	See label	
	Acti-dione PM	See label	
RUSSIAN-OLIVE			
Fungus leaf spot	copper	See label	Spray twice, 10 days apart, starting as leaves unfold.
SERVICEBERRY, SHADBUSH - See Amelanchier			
SPRUCE - See Pine			
SUMAC			
Fungus leaf spots	maneb, 80% WP	1½-2	Apply when disease is first seen. Repeat as needed at 7- to 10-day intervals during rainy spring periods.
	sulfur, 95% WP	4-6	
SYCAMORE, PLANETREE, BUTTONWOOD			
Anthracnose,[6] Fungus leaf spots, Leaf blight	benomyl, 50% WP	1	Spray 3 times: just before buds break open, budbreak, and when leaves are expanded. Thorough coverage is required.
	copper	See label	
	mancozeb, 80% WP	1½-2	
	maneb, 80% WP	1½-2	
	dodine, 65% WP	1	
	captafol, 4F	2 pts.	
	zineb, 75% WP	1½-2	
Powdery mildew	benomyl, 50% WP	½-1	Spray 2 or 3 times, 7 to 10 days apart, starting when disease first appears.
	sulfur, 95% WP	4-6	

Plant and disease	Suggested fungicides	Rate[1] (lb./100 gal. unless specified otherwise)	Application and remarks
TAXUS - See Yew			
TULIPTREE Fungus leaf spot	copper	See label	If severe, spray 2 or 3 times, 10 days apart. Start as buds break open.
Powdery mildew	benomyl, 50% WP Karathane, 22.5% WP	½-1 ½-1	If severe, spray twice, 10 days apart, starting when mildew first appears.
VIBURNUM Powdery mildew	benomyl, 50% WP sulfur, 95% WP Karathane, 22.5% WP	½-1 1½ ½	Spray 2 or more times, 7 to 10 days apart. Start when disease first appears.
WALNUT, BUTTERNUT Anthracnose, Yellow leaf blotch, Fungus leaf spots or blights	benomyl, 50% WP dodine, 65% WP zineb, 75% WP mancozeb, 80% WP maneb, 80% WP	1 ½-1 1½-2 1½-2 1½-2	Spray 3 or 4 times at 2-week intervals, starting when the leaves begin to unfold. Thorough coverage is required.
Bacterial blight (of Persian or English walnut)	copper streptomycin formulations	See label See label	Spray 3 times: when flowering starts, at full bloom, and at petal-fall.
WILLOW Tar spot, Leaf blight or scab, Black canker, Spot anthracnose	copper zineb, 75% WP mancozeb, 80% WP maneb, 80% WP dodine, 65% WP	See label 1½-2 1½-2 1½-2 ½-1	Spray 3 times, 10 days apart, starting as the buds open. Zineb, maneb, and mancozeb also control rust.
Powdery mildew, Rust	sulfur, 95% WP	4-6	Apply 2 or more times, 7 to 10 days apart. Start when disease first appears.
WITCHHAZEL Powdery mildew	benomyl, 50% WP Karathane, 22.5% WP sulfur, 95% WP	½-1 ½-1 3-4	Spray 2 or more times, 7 to 10 days apart. Start when disease appears.
Fungus leaf spot	copper *plus* benomyl, 50% WP	See label ½-1	If severe, spray twice, 10 days apart. Start as leaves begin to unfold.

Plant and disease	Suggested fungicides	Rate[1] (lb./100 gal. unless specified otherwise)	Application and remarks
YEW (Taxus)			
Twig blight	bordeaux mixture	4-4-100	Apply when new growth emerges. Repeat twice more at 7- to 10-day intervals.
ALL WOODY PLANTS			
Seed decay, Damping-off, Seedling blights	thiram, 50-75% WP captan, 50-75% WP	See remarks See remarks	Apply 2 oz./lb. of seed. If damping-off starts, drench seedbed (4 T./gal.) when first seen. Follow label directions.
	DMTT, Mylone	See label	Apply as a soil drench 2 to 3 weeks prior to planting in nursery beds.
	fenaminosulf (Dexon) etridiazol (Truban)	See label See label	Apply as a soil drench after plants are set; repeat at 2- to 4-week intervals. Dexon controls only *Phytophthora* and *Pythium*; may be combined with captan or thiram.
Wood rots or decays	thiram, 75% WP copper naphthenate benomyl, 50% WP sodium o-phenylphenate	1 See label ¼ 2	Apply thinly in an asphalt or other nonfortified tree wound preparation. See also Additional Comment 2 on next page.
	denatured alcohol, 70% formaldehyde, 4%		Dip tools between trees to disinfect them.

[1]The rates given are based on hydraulic application. If using a mistblower, follow label directions.
[2]Whenever possible, benomyl should be alternated with another fungicide or mixed with it to avoid resistant strains or races of fungi from developing.
[3]Copper fungicides include fixed or neutral copper compounds and bordeaux mixture (usually 4-4-100 or 8-8-100).
[4]Arbotect 20-S and MBC-phosphate or carbendazin materials have not been adequately tested in most states by specialists in tree pathology; therefore, they cannot be fully recommended at this time.
[5]Do not use 2,4,5-T around the home, recreational areas, pond or ditch banks, or similar sites. This treatment helps prevent spread into nearby healthy trees.
[6]Recommended for the leaf-blight stage of anthracnose only.

Additional Comments

1. The vigor of unthrifty and undernourished woody ornamentals, commonly susceptible to a variety of diseases and environmental stresses, can often be greatly improved by periodic applications of fertilizer and timely watering. Soil tests are always suggested prior to feeding, especially if a soil (or lawn) fertilization program has been in effect. In general, a 10-10-10 (NPK) fertilizer at the rate of 2 to 4 pounds per inch of trunk diameter at breast height can be applied in a series of holes evenly distributed in the ground beneath the tree and extending well beyond the drip line.

2. Proper selection of planting site, planting and spacing, pruning, winter protection, selection of well-adapted planting materials, control of other diseases and pests, and avoidance of unnecessary wounding will aid in control of a wide range of diseases.

   Prune during dry weather and sterilize tools frequently between cuts, using a fresh 10-percent solution of liquid household bleach, 70 percent denatured (or radiator antifreeze-type) alcohol, or formaldehyde. When pruning or removing diseased wood, paint the newly exposed inner bark and sapwood with a germicidal or fungicidal coating. Shellac is useful for diseases caused by bacteria, such as fire blight. Follow the shellac with a tree wound paint containing benomyl (Benlate) fungicide 50% WP at the rate of 1 gram in 5,000 grams (2-2/3 oz./100 gal.). This mixture, although harmless to living bark, is toxic to spores of such canker- and wilt-producing fungi as *Botryosphaeria*, *Ceratocystis*, *Cytospora (Valsa)*, and *Verticillium*.

3. Wetting, spreading, and sticking agents (surfactants) are often added to spray mixtures when spraying hard-to-wet foliage such as that of conifers, broadleaf evergreens, boxwood, and roses. A few commercial spreader-stickers available for tank mixing include Biofilm Spreader-Sticker, Chevron Spray Sticker, Citowett Plus, Filmfast Spreader-Sticker, Miller Nu-Film-P and -17, De-Pester Spreader-Activator, DuPont Spreader-Sticker, and Aqua T Non-ionic Organic Wetting Agent. Commercial spreaders include Chevron Spreader, Chipco and Rhodia Spreader-Activator, Flo-Wet, Multi-Film L and X-77, Ortho X-77 Spreader, Pinolene, Sure Spred, Surfactant II, Triton B-1956, Tween 20, Fluxit, Sanomerse 80, and Penex. The fungicide label usually indicates any restrictions in selection of compatible surfactants. Use these commercial preparations according to label directions. The addition of excess wetting, spreading, or sticking agent may cause excess runoff and result in a poor spray deposit.

4. Winter drying (leaf scorch) of broadleaf evergreens, including magnolia, holly, rhododendron, and boxwood, can often be prevented by applying an antidessicant such as Folicote, Foli Guard, Vapor Guard. or Wilt Pruf NCF, according to label directions. Apply to the upper surfaces of leaves in late November or early December and repeat again in midwinter.

5. In general, spray *only* when disease is a known threat. Annual sprays or routine spray schedules are required for relatively few diseases in home, recreational, or industrial plantings. Most fungicide sprays are designed to protect against infection. To be effective, the fungicide must be on the plant *before* infection occurs. Rainy, foggy, or very humid weather favors infection by practically all fungi and bacteria. When possible, therefore, spray schedules should be altered to provide maximum fungicidal protection during rainy periods.

SPRAY CHART FOR SOME IMPORTANT DISEASES OF FLOWERS AND OTHER NONWOODY ORNAMENTALS

M.C. Shurtleff and B.J. Jacobsen

Disease	Chemicals for control	Remarks
Damping-off, Seed rot, Seedling blights	captan	Apply as seed treatment any time before planting. Grow plants in sterilized (pasteurized) soil where feasible.
Storage decay	zineb, captan, Botran, or benomyl	Spray, dust, or dip before shipping or placing in storage.
Cutting rots, Damping-off, Crown and stem rots, Root rots	PCNB (Terraclor), captan-PCNB mixtures, Banrot, Zyban, or benomyl	For *Botrytis*, *Rhizoctonia*, *Sclerotinia*, and *Sclerotium* stem and root rots *only*. Apply as a soil drench (1 pt. per sq. ft.) or work into upper 2 to 4 inches of soil before planting. Check labels for crop registrations.
	fenaminosulf (Dexon), etridiazol (Truban or Terrazole), or Banrot	For *Aphanomyces*, *Phytophthora*, and *Pythium* stem and root rots (water molds) *only*. Usually applied as a soil drench at intervals of 2 to 4 weeks. Check label instructions.
Leaf and flower spots caused by fungi	benomyl *plus* captan, zineb, maneb, mancozeb, ferbam, folpet (Phaltan), or chlorothalonil (Daconil 2787, Exotherm Termil)	Benomyl *plus* captan, zineb, chlorothalonil, or mancozeb also gives *Botrytis* control, as does Botran. Check labels for specific information. Applications are needed at intervals of 5 to 7 days in rainy weather and every 7 to 10 days in drier weather. Check labels for crop registrations.
Rusts	zineb, maneb, mancozeb, ferbam, oxycarboxin (Plantvax), or cycloheximide (Acti-dione)	Applications are usually needed at intervals of 7 to 10 days starting when rust first appears. Check labels for crop registrations.

Disease	Chemicals for control	Remarks
Powdery mildews	benomyl, sulfur, dinocap (Karathane), piperalin (Pipron), parinol (Parnon), or cycloheximide (Acti-dione PM)	Frequent applications and thorough coverage are essential. Cycloheximide, sulfur, and dinocap may cause plant injury especially in hot weather (85° F. or above). Check labels for current crop registrations.
Bacterial flower, leaf, and shoot blights	streptomycin formulations or fixed copper, 50-56% Cu	Follow manufacturer's directions strictly, or plant injury may result.
Wilt diseases (most *Fusarium* and *Verticillium*), Crown and root rots, Fasciation, Crown gall	steam (180° F. for 30 minutes or 160° F. for 1 hour), methyl bromide, chloropicrin, Vorlex, or Vapam Soil Fumigant	Treat soil several days to a month before planting. Carefully follow the manufacturer's directions, as chemicals are *very* toxic and some may be used only be licensed commercial applicators. Also treat containers, work surfaces, benches, potting table, tools, and other equipment.
Soil nematodes (including root-knot and root-lesion nematodes)	Same as wilt diseases (above) or apply 1,3-D (D-D), ethylene dibromide (EDB), or Dorlone	
Viruses, Mycoplasmas	Apply insecticides as recommended by University of Illinois entomologists	Control insects--especially leafhoppers, aphids, and thrips--that transmit the causal agents. Rogue the first infected plants.

EQUIPMENT FOR APPLICATION OF PESTICIDES TO FIELD CROPS

L.E. Bode, B.J. Butler

Proper application of a pesticide requires the use of the right equipment for the purpose intended. Many types of application equipment are available, including fumigators, granular applicators, and aerial and ground sprayers.

Low-Pressure Field Sprayers

Low-pressure sprayers, the most commonly used equipment for pesticide application to field crops, are used to apply preemergent or postemergent pesticides to control weeds, insects and diseases. Low-pressure sprayers may be tractor mounted, pull-type, or self-propelled; each type is available in many models.

All field sprayers are composed of several basic components (Figures 1 and 2). Both systems shown include a pump, a tank, an agitation system, a flow-control assembly, and a distribution system with adequate controls. Figure 1 illustrates the basic system for a positive displacement pump, such as piston, gear, roller, or diaphragm pump. Figure 2 illustrates a system with a centrifugal pump. Note that the plumbing and valve locations for the centrifugal pump are different from those for the positive displacement pump.

Pumps

The pump is the heart of the sprayer. Several kinds of pumps can be used for spraying field crops. Each kind has certain limitations that determine when it can be used. The kinds of pumps available, along with their characteristics, are given in Table 1. Only the centrifugal and the roller pumps are extensively used for application of pesticides to field crops.

Roller pumps are popular for smaller field sprayers and tractor-mounted sprayers. The roller pump is considered a positive displacement pump and is self-priming. It requires a bypass valve and a return line to control pressure so that damage does not occur when the sprayer boom is turned off. Some owners have had problems with excessive wear of the rollers when wettable powders are used. Other owners have kept the pump life long by keeping the pump running at all times when using wettable powders, by proper maintenance and storage of the pump, and by keeping abrasive materials out of the sprayer.

Centrifugal pumps are becoming increasingly popular because of their durability, simplicity, and ability to handle abrasive materials. The initial cost of a centrifugal pump is somewhat higher than that of a roller pump. The centrifugal pump is not a positive displacement pump. The capacity of the centrifugal pumps available for applying pesticides is much greater than needed, so the pump output must be restricted. The output can be completely stopped without damage to the pump. Such pumps have the high volumes needed to supply tank agitators. The impellers should usually run between 3,000 and 4,500 rpm, so some type of speed step-up is needed if the pump is to be operated by the tractor power take-off. Many centrifugal pumps are run by a hydraulic motor. This type of pump is limited to operating pressures of 50 to 60 pounds per square inch (psi), but this is sufficient for most spraying jobs in field crops.

Figure 1. Basic sprayer system for a positive displacement pump.

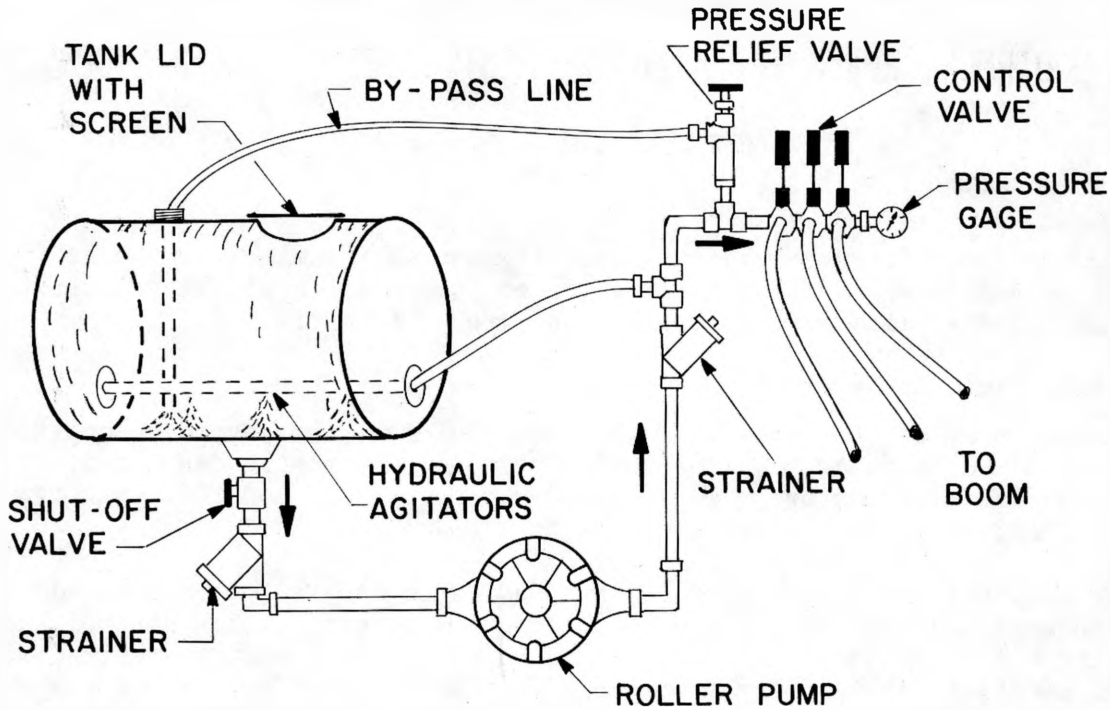
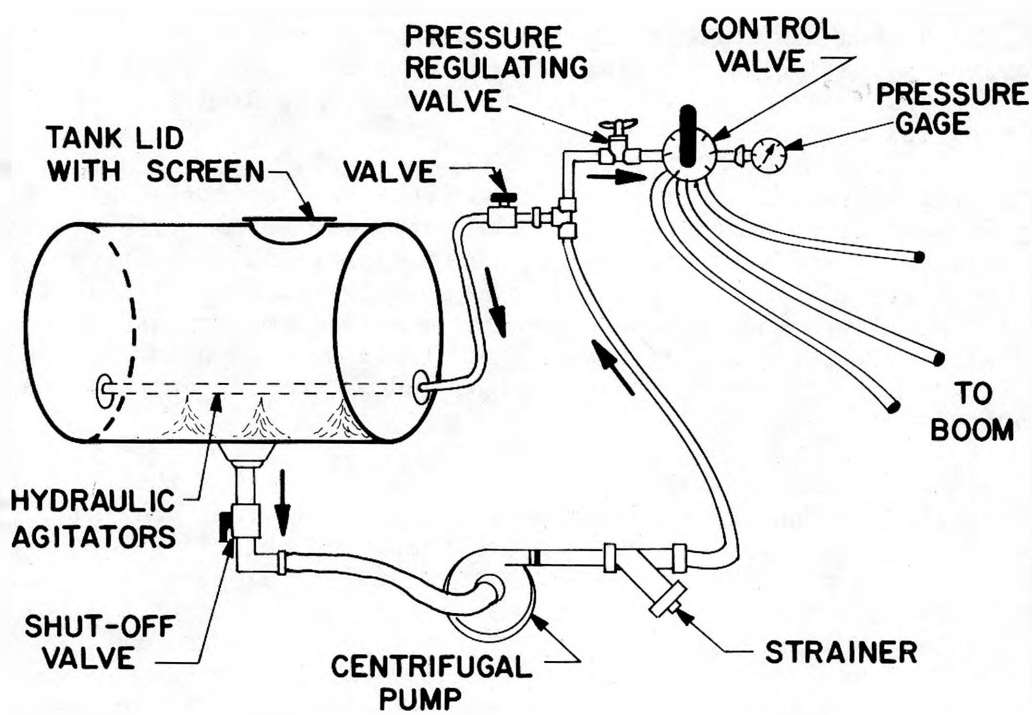


Figure 2. Basic sprayer system for a centrifugal pump.



Regardless of the type, the pump must provide the necessary flow rate at the desired pressure. It should pump enough spray liquid to supply the gallons per minute required by the nozzles plus the gallons per minute (gpm) required by the tank agitators and still have a reserve capacity of 10 to 20 percent.

Table 1. Pump Characteristics

Pump type	Capacity (gpm)	Max. press. (psi)	Material handled	Comments
Centrifugal	0-150	60[a]	Abrasive	Low wear, not self-priming, high speed necessary
Roller	0-35	300	Nonabrasive	Easily serviced, short life with wettable powders
Piston	0-60	800	Abrasive	Long life, heavy, expensive
Gear	5-20	100	Nonabrasive	Cannot be used with wettable powders
Diaphragm	1-10	100	Abrasive	Long life, low volume

[a]Multi-stage units develop higher pressures.

Pumps are not 100 percent efficient, but have losses from factors such as drive friction and pump leakage. When estimating the pump horsepower needed for an application, an efficiency (Eff) of 50 to 60 percent should be used.

Horsepower required to drive the pump can be determined by the formula:

$$\text{Hp} = \frac{(\text{gpm})\ (\text{psi})}{1{,}714\ (\text{Eff})}$$

Tanks

Sprayer tanks should have sufficient capacity, be easy to fill and clean, be corrosion resistant, have a shape suitable for mounting and effective agitation, and have adequate openings for pump and agitation connections.

Galvanized steel tanks are inexpensive and can be made in almost any shape or size. They are easy to repair or modify. Corrosion is the biggest drawback. Even with protective coatings, chemicals cause rapid rusting. Rust flakes off, plugs nozzles, clogs strainers, and damages pumps. Galvanized tanks and recycled barrels are suitable for most pesticides, but should not be used with the more corrosive liquid fertilizers and insecticides and nematicides.

Polyethylene tanks are relatively inexpensive and can be made in many sizes and shapes. They are noncorrosive and can be used with liquid fertilizers except ammonium phosphate solutions or complete-analysis liquid fertilizers. Stainless steel tanks are needed for these materials. Polyethylene tanks are tough and durable. However, if the tank is cracked or broken, it must be replaced because there is no effective way to repair it. Polyethylene breaks down under ultraviolet light, so these tanks should be kept out of the sun when not in use.

Aluminum tanks are moderate in cost, resist corrosion, and are suitable for many chemicals. However, they should not be used for liquid nitrogen solutions with a phosphoric acid base.

Fiberglass tanks are widely used on all types of sprayers and applicators. Tanks of this material are also used as nurse tanks. Fiberglass is strong and durable, but will break or crack under impact. One advantage of fiberglass over polyethylene is that there are repair kits for "on farm" use, or a dealer can make repairs. Fiberglass tanks are about equal to aluminum in cost and can be used with most kinds of chemicals. They may, however, be affected by some kinds of solvents.

Stainless steel is the highest quality material for pesticide and fertilizer applicator tanks. It is strong, durable, and resistant to corrosion by any crop chemical. Because it is the most expensive material commonly used for tanks, only equipment with high annual use needs to be equipped with stainless steel tanks.

When barrels or small metal tanks are used, tank mounting is not critical. However, polyethylene and fiberglass tanks must be properly mounted on a "saddle," which supports the tank over a large area. Without a saddle, the weight of the liquid may break the tank as the sprayer bounces over obstructions or rough terrain.

Tank Agitation

Agitation requirements depend largely on the chemical being applied. Soluble liquids and powders do not require any special agitation once they are in solution. However, both emulsions and wettable powders will usually separate if they are not agitated by some means. Any separation will have a harmful effect on the final spray concentration, so thorough agitation is a must for these chemicals. Agitation can be done either by mechanical paddle wheels or by a hydraulic jet. Jet agitation is simple and effective, provided that the device is installed correctly. Jet agitation can be achieved through holes drilled in a pipe running the entire length of the tank or through special agitator nozzles. They should receive fluid from the discharge side of the pump and not merely from the bypass line. The amount of flow needed for agitation depends on the chemical used, as well as on the shape of the tank.

For a simple orifice jet agitator, a flow of 6 gpm for every 100 gallons of tank capacity is usually adequate. There are several types of suction venturi attachments available that will help stir the tank with less flow. If these are used, the agitator flow from the pump can be reduced to 2 to 3 gpm for every 100 gallons of tank capacity.

Regardless of the type of jet agitator used, it should be fastened securely inside the tank. Keep the jet submerged at all times to prevent foaming. Some wettable powder suspensions can wear a hole through the tank, so the high-speed stream coming from the agitator should pass through at least 12 inches of liquid before hitting the tank.

Although hydraulic agitation will keep a suspension from settling, it is not intended to mix the chemical and form the suspension initially. It is usually best to make a slurry in a separate container first, then add it to the tank. Detailed mixing instructions are usually printed on the label of the chemical. Once you have mixed a tank of wettable powder, try to use the entire tank before stopping. Do not stop agitation when moving from field to field.

Flow-Control Assembly

When a roller (positive displacement) pump is used, the flow-control assembly consists of a pressure regulator or relief valve, a pressure gage, and a cut-off or control valve (Figure 1). Bypass pressure regulators generally have a spring-loaded ball or diaphragm that opens with increasing pressure so that excess flow is bypassed back to the tank. Pressure regulators are adjustable to permit changes in the working pressure of the system.

Controlling nozzle pressure and flow when a centrifugal pump is used does not require a pressure relief valve. The pump output can be regulated with a simple gate or globe valve (Figure 2). For accurate pressure control, special throttling valves requiring several turns to open completely are available. Electric-controlled throttling valves are now available for remote pressure control. These valves are especially useful for enclosed cabs. A second valve in the agitation line is used to regulate the amount of agitation required. A valve-controlled bypass line is sometimes added to the tank from the pressure side of the pump to control pressure. In this case, the amount of solution returned to the tank is excessive and may cause a foaming problem with some pesticides.

A pressure gage must be included in every sprayer system, because nozzles are designed to operate within certain pressure limits. The importance of a good pressure gage cannot be overemphasized. The pressure gage must be used for calibrating and while operating in the field. Select a gage for the pressure range you will be using. A range of 0 to 60 psi is adequate for herbicides and most other pesticides. When a 100-psi gage is used for operating at 20 psi, accurate pressure adjustment is difficult, if not impossible.

The boom cut-off valve or the control valve allows the sprayer boom to be shut off while the pump and the agitation system continue to operate. A quick-acting control valve is desirable. Electric solenoid valves, which eliminate inconvenient hoses and plumbing, are available.

Strainers and Screens

To prevent damage, a strainer should be used between the tank and the pump, especially with roller pumps and other positive displacement pumps. A 50-mesh strainer is recommended. A strainer is not usually needed to protect a centrifugal pump, except against large pieces of foreign material. It is important that the inlet of a centrifugal pump not be restricted, so if a strainer is used, it should be cleaned frequently. A 50-mesh strainer should be located in the line to the boom, as shown in Figures 1 and 2.

Each nozzle must have a screen sized to stop any particle that may plug the nozzle orifice. Screens are not usually required with the large flooding flat-spray nozzles. A check-valve type of strainer that eliminates dripping while turning is desirable. For wettable powders, 50-mesh screens should be used to help prevent clogging by the powder. Finer screens, such as 100 mesh, can be used to apply liquid concentrates, emulsions, or soluble powders.

Distribution Systems

Spray lines must be properly sized for the system. It is very important that the suction hose be properly sized. The hose should be airtight, noncollapsible, as short as possible, and as large as the pump intake. A collapsed suction hose can restrict flow and "starve" a pump, causing decreased flow and damage to pump seals. When pressure cannot be maintained, the suction line is always a prime suspect.

Other lines, especially those between the pressure gage and the nozzles, should be as straight as possible, with a minimum of restrictions and fittings. The proper size of these lines will vary with the size and capacity of the sprayer. A high but not excessive fluid velocity should be maintained throughout the system. If lines are too large, the velocity will be so low that the pesticide will settle out and clog the system. If lines are too small, an excessive drop in pressure will occur. A flow velocity of 5 to 6 feet per second is recommended. The following are suggested hose sizes for various flow rates:

Pump output (gpm)	Hose size	
	Suction	Pressure
1-12	3/4"	5/8"
13-25	1"	3/4"
26-50	1 1/4"	1"
51-100	1 1/2"	1 1/4"

Boom stability is important in achieving uniform spray application. The boom should be relatively rigid in all directions. Swinging back and forth or up and down is undesirable. The break-away hinge arrangement of the boom should be dampened so that the boom is rigid in the fore and aft direction. The boom should be constructed to permit folding for transport. Check for interference of the folded booms with tractor cabs and roll bars. Boom height should be adjustable from about 20 inches up to 4 feet above the ground.

Certain commonly-used chemicals react with some plastic materials. It is important to check with the sprayer manufacturer and the chemical manufacturer for compatibility.

Nozzles

Proper nozzle selection and use is more important than any other aspect of pesticide application. Nozzles determine how much spray is applied, how uniformly it is applied, how well the intended surface is covered, and how much drift occurs. A conscientious operator will select nozzles that give the largest drop size and still give adequate coverage at the desired application rate and pressure. Although nozzles have been developed for practically every kind of spray application, only a few are commonly used for applying pesticides to field crops (Figure 3).

Regular flat-fan nozzles are recommended for most broadcast spraying of herbicides and some insecticides where foliar penetration and coverage is not required. When applying herbicides with flat-fan nozzles, the pressure should be between 15 and 30 psi, never over 40 psi. The flat-fan nozzle is normally spaced on 20-inch centers with a boom height of 17 to 23 inches. This nozzle produces a flat-fan spray pattern and is available in several selected spray fan angles. The outer edges of the pattern have lower volumes, which means that overlapping of adjacent patterns is required for uniform coverage. Overlapping should be about 30 to 50 percent of the nozzle spacing.

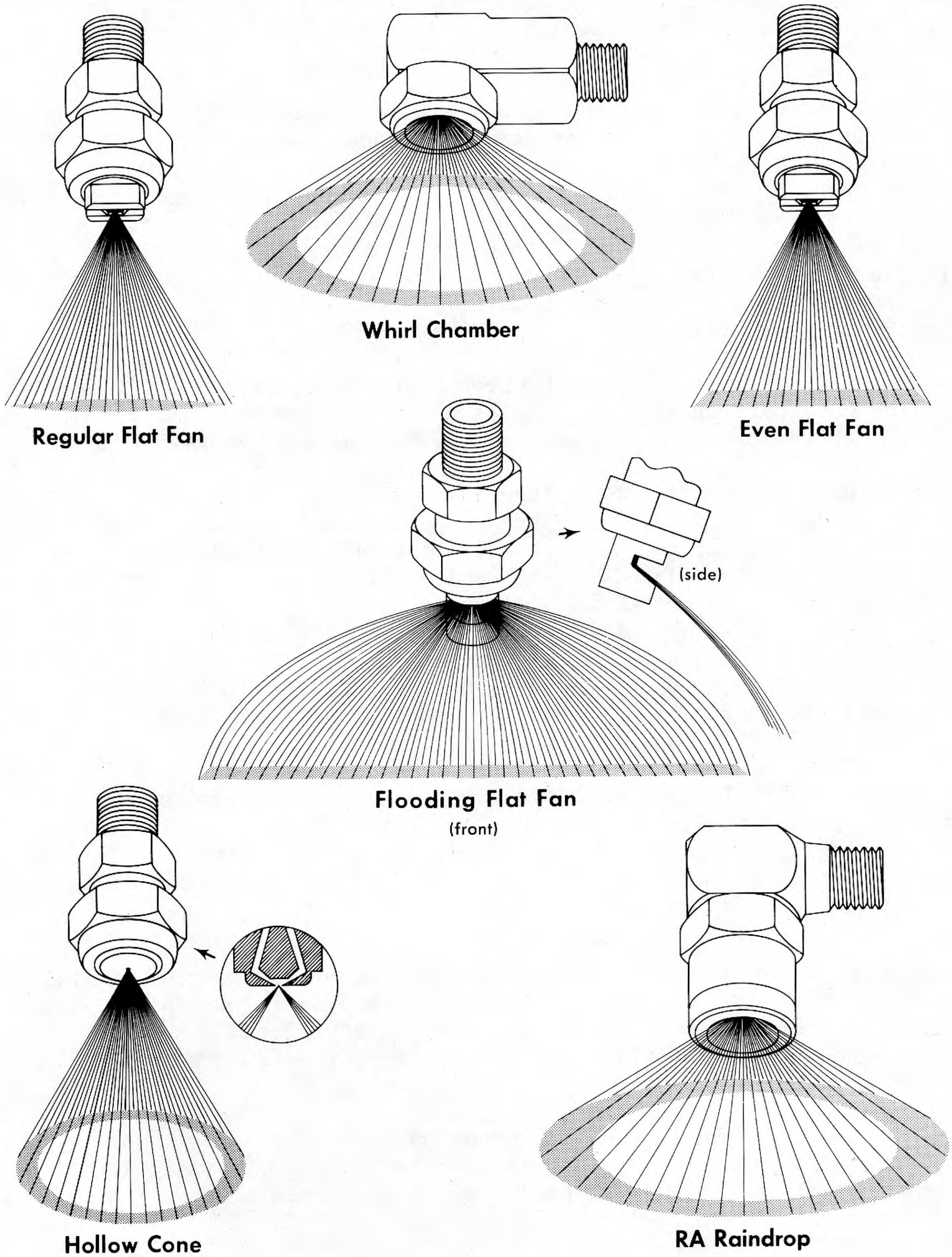


Figure 3. Nozzle Spray Patterns.

At low pressures, flat-fan nozzles produce droplets of medium-to-coarse size that are not so susceptible to drift as finer drops produced at pressures above 40 psi. However, drifting will occur, and herbicides such as 2,4-D and Banvel can cause damage to sensitive crops at great distances.

Even flat-fan spray nozzles are designed to produce an even pattern with a full dosage of chemical across its entire width. This nozzle should be used for banding chemicals over the row.

Flooding flat-fan nozzles are used for applying herbicides and mixtures of herbicides and liquid fertilizers. This kind of nozzle produces a wide-angle, flat-fan pattern. For applying herbicides the nozzle spacing should be 60 inches or less. These nozzles are best for reducing drift when operated within a pressure range of 8 to 20 psi. Pressure changes affect the width of the spray pattern in this nozzle more so than in the flat-fan nozzle. Also, the distribution pattern generally is not as uniform as the regular flat-fan tip. Therefore, the best distribution is achieved when the nozzle is mounted 30 to 45 degrees above horizontal at a height to obtain double coverage, or 100 percent overlap.

Whirl chamber nozzles have a whirl chamber above a conical outlet. These nozzles produce a hollow cone pattern with fan angles up to 130 degrees, and are used mainly on herbicide incorporation kits. The recommended pressure range is 5 to 20 psi.

Raindrop nozzles have recently been introduced to reduce drift. The specially designed raindrop cap produces very large drops in a hollow cone pattern at pressures of 20 to 60 psi. The RA Raindrop nozzles are used on herbicide incorporation kits. However, when used for broadcast application, the nozzle should be rotated 30 to 45 degrees from horizontal to obtain uniform distribution.

Hollow cone nozzles are used primarily when penetration of plant foliage is essential for effective insect and disease control, and when drift is not a major concern. These nozzles produce small drops that penetrate under leaves more effectively than do the droplets produced by flat-fan nozzles.

Nozzle tips are available in a variety of materials, but brass is the most common. Although brass is relatively inexpensive, tests have shown that it is highly susceptible to abrasion by materials such as wettable powders. Stainless steel or newly developed snythetic plastics may be more economical for spraying abrasive materials.

Calibration of Low-Pressure Field Sprayers

The performance of any pesticide depends on the proper application of the correct amount of chemical. Most performance complaints about agricultural chemicals are directly related to errors in dosage or to improper application. An applicator should always make sure his equipment is applying the specified amount of material uniformly over a given area.

The amount of spray applied per acre depends on three variables: nozzle flow rate, ground speed of the sprayer, and sprayed width per nozzle. Nozzle flow varies with the size of the nozzle tip and the nozzle pressure. Remember that flow through a nozzle increases as the square root of the pressure. Therefore, to double the nozzle flow rate, pressure must increase four times. This means that pressure cannot be used to make major changes in application volume, but can be used to correct for minor changes due to nozzle wear and other factors.

Doubling the ground speed of a sprayer reduces the gallons of spray applied per acre by one-half. Also, increasing the sprayed width per nozzle (nozzle spacing) decreases the amount of spray applied per acre.

Nozzle Tip Selection

Regardless of the type of nozzle you use, its size must be carefully chosen by the operator, not the sprayer manufacturer. Some manufacturers advertise certain "gallons-per-acre nozzles," but this rating is accurate only under standard conditions (usually 30 psi, 4 mph, and 20-inch spacing). The gallons-per-acre rate is useless if conditions vary from the standard. A surer way of choosing nozzles is by the gallons-per-minute (gpm) rate at a specified pressure. The gallons per minute required from each nozzle for the job to be done is:

$$GPM = \frac{GPA \times MPH \times W}{5{,}940} \qquad \text{Equation 1}$$

where:

GPM = flow rate from each nozzle in gallons per minute
GPA = desired application rate in gallons per acre
MPH = sprayer travel speed in miles per hour
W = width sprayed per nozzle in inches
a) for broadcast spraying, W is nozzle spacing
b) for band spraying, W is band width
c) for row-crop spraying, $W = \dfrac{\text{row spacing}}{\text{number of nozzles per row}}$

Nozzle manufacturers' catalogs give nozzle flow rates at various pressures. Once the flow rate and recommended operating pressure are known, the correct size for the nozzle tip can be selected.

Precalibration Check

Install the selected nozzle tips, partly fill the sprayer tank with water, and operate the sprayer at a pressure within the recommended pressure range. Place a container, such as a quart jar, under each nozzle and check to see if all the jars fill in about the same time. Replace any nozzle having an output of 5 percent more or less than the average of all the nozzles, or having an obviously different fan angle or a nonuniform appearance in spray pattern.

To obtain uniform coverage, the nozzle spray angle, nozzle spacing, and nozzle height must be considered. With different spray angles and operating pressures, the height must be adjusted for uniform coverage. Manufacturers' manuals give nozzle heights for various spray angles and nozzle spacings. Do not use nozzles with different spray angles on the same boom.

Worn or partly plugged nozzles produce nonuniform patterns. Misalignment of nozzle tips is a common cause of uneven coverage. The boom must be level at all times to maintain uniform coverage. If one end of the boom is allowed to droop, skips and uneven coverage will result. One method to check nozzle height for overlap required to produce the most uniform coverage is to spray on a warm surface such as a road and watch the drying rate. Adjust the height to eliminate excess streaking.

Calibration Procedure

Accurate calibration is the only way to know how much pesticide is being applied. In addition to calibrating the sprayer at the beginning of the season, you should also calibrate every few days of use. New nozzles do not lessen the need to calibrate, because some nozzles "wear in" and will increase discharge for the first few hours of use. There are many methods for calibration of a sprayer, but they are all based on determining the amount of chemical applied to a measured land area. The method that follows can be used for boom, band, directed, and row-crop spraying. Once the method is learned, frequent checks of application rates can be made quickly and easily.

Step 1. Lay out a known distance in the field to be sprayed or in a field with similar soil conditions. A suggested distance is 176 feet for speeds up to 8 mph. To obtain more accurate settings for speeds above 8 mph, stake out 352 feet. At the engine throttle setting and in the gear you plan to use during spraying with a loaded sprayer, determine the travel time between stakes in each direction. Average these speeds, and use Equation 2 or Table 2 to determine the travel speed.

$$\text{Speed (MPH)} = \frac{\text{distance (feet)} \times 60}{\text{time (seconds)} \times 88} \qquad \text{Equation 2}$$

Example: If it takes 20 seconds to travel 176 feet, the ground speed =

$$\frac{176 \times 60}{20 \times 88} = \frac{120}{20} = 6 \text{ MPH}$$

Table 2. Travel Speed

Distance (feet)	Speed (MPH) 3	3.5	4	4.5	5	6	8	10	12	15
				(seconds)						
88	20	17	15	..	..	..	..	..	..	..
176	..	..	30	27	24	20	15	..	..	..
352	..	..	..	..	..	..	30	24	20	16

Once you have decided upon a particular speed, record the throttle setting and drive gear used.

Step 2. Using Equation 1 or a nozzle manufacturer's catalog, determine the output needed for each nozzle in gallons per minute (gpm). Convert this figure to ounces per minute (opm) by using Equation 3.

$$\text{OPM} = \text{GPM} \times 128 \qquad \text{Equation 3}$$

Example: To broadcast 20 gallons per acre (gpa) at a speed of 6 miles per hour with a nozzle spacing on the boom of 40 inches, you need a nozzle flow rate of 0.81 gallons per minute, or 103 ounces per minute.

$$\text{GPM} = \frac{\text{GPA} \times \text{MPH} \times \text{W (nozzle spacing, inches)}}{5{,}940}$$

$$\text{GPM} = \frac{20 \times 6 \times 40}{5{,}940} = 0.81$$

$$\text{OPM} = \text{GPM} \times 128 = 0.81 \times 128 = 103$$

Table 3 may be used in place of the formulas. To use the table, locate the gallons per acre of spray volume selected. Follow across to the column marked with the ground speed determined in step 1. The factor at the intersection of these two columns is ounces per minute per inch of spray width. To determine the output required per nozzle, multiply the factor in the table times the spray width per nozzle.

Example: Speed = 6 MPH; volume = 20 GPA; nozzle spacing (W) = 40 inches. From the table, the factor for OPM is 2.59. The nozzle output required is 2.59 x 40 = 103 OPM.

Table 3. Nozzle Output

Volume	Speed (MPH)										
(GPA)	3.5	4	4.5	5	6	7	8	9	10	12	15
	(OPM per 1 inch of spray width)										
5	.38	.43	.48	.54	.65	.75	.86	.97	1.08	1.29	1.62
10	.76	.86	.97	1.08	1.29	1.51	1.72	1.94	2.15	2.59	3.23
15	1.13	1.29	1.45	1.62	1.94	2.26	2.59	2.91	3.23	3.88	4.85
20	1.51	1.72	1.94	2.15	2.59	3.02	3.45	3.87	4.31	5.17	6.46
30	2.27	2.59	2.91	3.23	3.88	4.52	5.17	5.82	6.46	7.76	9.70
40	3.02	3.44	3.88	4.30	5.18	6.04	6.90	7.74	8.62	10.34	12.92

Step 3. Measure the output in ounces per minute by collecting the water from a representative nozzle. Adjust the pressure until the amount collected is the same as that determined in step 2. Check another nozzle to determine if its output is also within 5 percent of the desired output. If it is impossible to obtain the desired output within the recommended range of operating pressures, select larger or smaller tips or a new operating speed, and recalibrate. Spray nozzles must be operated within the recommended pressure range.

Step 4. Determine the amount of pesticide needed for each tank or for the acreage to be sprayed, and add this amount to a partly filled tank of water. Then add water to the desired level.

Step 5. Operate the sprayer in the field at the ground speed determined from step 1 and under the pressure determined from step 3. After spraying a given number of acres, check the liquid level in the tank to verify that the proper application volume is being dispersed.

Step 6. From time to time check the nozzle flow rate. Adjust the pressure to compensate for small changes in nozzle output resulting from nozzle wear or variations in other spraying components. When the output has changed 10 percent or more from that of a new nozzle, or when the pattern has become uneven, replace the nozzle tips and recalibrate.

Cleaning and Storage

Cleaning of spray equipment is necessary to prevent injury to crops susceptible to the previously applied pesticide. Some materials will cause the equipment to deteriorate if allowed to remain in the sprayer for an extended period.

To remove residues of oil-based herbicides, such as esters of 2,4-D and similar materials, rinse the sprayer with kerosene, diesel fuel, or a similar light oil (not gasoline).

Equipment in which amine forms or water-soluble liquids have been used needs to be thoroughly rinsed with a water-detergent solution (2 pounds of detergent in 30 to 50 gallons of water). Water-soluble dry materials should be treated as water-soluble liquids. Allow the water-detergent solution to circulate through the system for several minutes.

After rinsing the equipment with either oil or water-detergent, fill the tank 1/2 to 3/4 full with a water-ammonia solution (1 quart of household ammonia to 25 gallons of water). A water-trisodium phosphate (TSP) solution (1 cup TSP to 25 gallons of water) may be substituted for the ammonia solution. Circulate through the system for a few minutes, allowing a small amount to go through the nozzles. Let the remainder of the solution stand at least 6 hours and then pump through the nozzles. Remove nozzles and screens and flush the system with two tankfuls of water.

Wettable powders are quite low in solubility. The sprayer must be flushed with water to physically remove the wettable powder. Accumulated powder in screens and around fittings must be rinsed with water under pressure for thorough cleaning. At least two flushings with clean water are usually necessary.

When storing your sprayer, add 1 to 5 gallons of lightweight oil (depending on tank size) before the final flushing. As water is pumped from the sprayer, the oil will leave a protective coating inside the tank, pump, and plumbing.

Nozzle tips and screens should be removed and stored in a can of light oil, such as diesel fuel or kerosene, to prevent corrosion.

Granular Applicators

Granular pesticides for weed or insect control must be applied accurately for effective and safe pest control. Both herbicides and insecticides may be broadcast before planting or applied after planting. The most common method is to apply granular pesticides in a band over the row by attaching applicators to the planter.

Most granular applicators use gravity flow with a rotating agitator for metering the granules through an adjustable orifice. Several factors can cause a variation in the application, for example: exposed area of the agitator; speed of the agitator; ground speed of the applicator; size, shape, and density of the granules; roughness of the field; and humidity and temperature.

Many granules look somewhat alike, but there is a wide variation in the size and density of the materials used to make granules. Therefore, a different applicator setting may be necessary for each chemical applied. A different setting may even be required for the same chemical formulated by two different manufacturers or in two batches by the same manufacturer.

Except for the orifice setting, ground speed is the most significant factor affecting the application rate. Calibration must be done at the same speed used in the field and it must be kept constant.

Proper placement of granules is very important. Some soil insecticides are placed in a narrow band over the seed and covered with a shallow layer of soil, and others are placed in a narrow band ahead of the press wheel. Herbicides are usually placed in a 12- to 16-inch band over the row.

Raising or lowering the spreaders will change the band width. Band width must be checked frequently because height changes can occur in different soil conditions.

Calibration of band granular applicators begins with reading the pesticide label to determine the recommended application rate and placement of the chemical. Use *pounds per acre* for all herbicides (banded and broadcast) and broadcast insecticides and fungicides. Use *ounces per 1,000 linear feet of row* for in-the-row insecticides and fungicides. Insecticide recommendations have traditionally been given as pounds of active insecticide per acre based on 40-inch row widths. However, if narrower rows are used, more material is needed per acre to maintain a constant amount of insecticide per foot of row. Most manufacturer and university recommendations are now given in ounces per 1,000 linear feet of row as well as in pounds per 40-inch-row acre. If a chemical manufacturer lists the application rate for in-the-row application as pounds per 40-inch-row acre only, the rate can be converted to ounces per 1,000 feet of row by multiplying by 1.22. Operator's manuals provided with the equipment give initial settings for desired rates. However, for precise application, you must properly calibrate the applicator with your pesticide in relation to your operating conditions.

Granular applicator calibration is based on determining how many ounces need to be distributed over a known distance. A step-by-step calibration procedure follows.

Step 1. Determine the number of ounces required for application over a known distance, for example, 1,000 feet. For in-the-row treatments the number of ounces is obtained directly from the label. For broadcast or band applications use the following formula:

$$\text{Ounces required} = \frac{\text{lb./A. x area treated (ft.}^2)}{2{,}700}$$

Area treated is the area actually covered with granules, and is the length of the measured course times width of spread for each applicator.

Example: Apply 20 lb./A. of Lasso 15G granules in a 14-inch band (14 inches = 1.2 feet). A 1,000-foot distance is to be used.

$$\text{Ounces required} = \frac{\text{20 lb./A. x 1,000 ft x 1.2 ft.}}{2{,}700} = \text{8.9 ounces}$$

Step 2. Adjust the initial setting on each applicator according to the equipment manufacturer's recommendation. Make the test run in the field to be treated so that speed and traction conditions will be constant.

Step 3. Disconnect the drop tube and collect the granules in a jar or bag while operating over the measured distance, for example, 1,000 feet.

Step 4. The granules collected should be measured by weight. Since the expelled pesticide will amount to only a few ounces, the granules can be weighed on a postal scale, baby scale, or food scale. Volume measurements may be inaccurate because of nonuniform settling or segregation of granules. If the amount collected is not equal to the ounces required, adjust the gage setting and repeat the calibration.

The application rate can vary from one day to the next or from one field to another. A simple method of regularly checking the application rate of each applicator is to place a strip of masking tape vertically on the inside of the applicator hopper. Then fill the hopper in increments of 1 or 2 pounds. After each increment is added, shake the hopper to settle the material, and mark the tape at the level of the chemical. Throughout the planting season, the application rate can be checked by simply reading the level of the chemical before and after treating a known number of acres.

HOW MUCH CHEMICAL SHOULD I PUT IN THE SPRAY TANK?

L.E. Bode

To determine how much pesticide to add to your spray tank, you must know three things:

1. The recommended pesticide rate
2. The capacity of the spray tank
3. The calibrated output of the sprayer

What Is the Recommended Rate?

The rate of pesticide to apply is determined from the label or university recommendations. The rate is usually given as pounds per acre for wettable powders and pints, quarts, or gallons per acre for liquids. Sometimes the recommendation is given as pounds of active ingredient (lb. a.i.) per area rather than amount of product per area. The active ingredient must be converted to actual product in this case.

How Much Water Does the Tank Hold?

This may seem a simple question, but it's where many mistakes are made. Don't believe anybody else--find out for yourself. At this point, somebody who "knows" may get you into trouble.

There are three ways to measure the tank's capacity:

Dip Stick Method. Be sure the tank is empty when you start. Also make sure that it is level.

You can use any convenient container, but know for sure what its capacity is. For example, you can use a "5-gallon" bucket, but measure to find out just how much it really holds.

Use the bucket or container to fill the tank. As it fills, mark each convenient quantity level on a dip stick. Be sure you note where the dip stick goes in, and put it in exactly the same place each time. On a big tank, 5-gallon marks may be too close together, so you might want to space the marks at larger intervals.

Sight Gauge. If the tank does not already have one, a simple plastic tube sight gauge is needed. A sight gauge is easy to make and easy to replace if the plastic tube gets clouded or plugged. Use the bucket-fill method described under "Dip Stick" to mark the quantities on the sight gauge. Be sure the top of the tube is vented into the top of the tank to give an accurate reading and prevent spillage.

Flowmeter. You can attach a flowmeter to the hose to measure the quantity of water as it goes into the tank. Good flowmeters are available at a modest price. If you do use one to check how much the tank holds, that would be a good time to calibrate the sight gauge, since you can mark the measured volumes as you fill the tank.

Regardless of how you measure it, the important thing is to know exactly how much water is in the tank.

What Is the Calibrated Output of the Sprayer?

To determine the spray rate in gallons per acre you need to calibrate the sprayer. Accurate and frequent calibration is essential. If you do not know a calibration method, contact your county extension office for a copy of the procedure recommended by the university.

How Many Acres Does a Tankful Cover?

Once you know the exact capacity of your tank and have your sprayer accurately calibrated, you can determine how many acres you can spray with every tankful of spray solution. Just divide the number of gallons the tank holds by the number of gallons per acre that you intend to apply.

How Much Chemical Should Be Put in the Spray Tank?

The amount of pesticide to add to the tank is determined by multiplying the acres sprayed per tankful times the recommended pesticide rate. Following are some sample problems.

Dry Formulation

An atrazine recommendation calls for 2 pounds of active ingredient per acre. You have purchased Aatrex 80WP (80% wettable powder). Your sprayer has a 400-gallon tank and is calibrated to apply 20 gallons per acre.

Since not all of the atrazine in the bag is an active ingredient, obviously you will have to add more than 2 pounds of the product to each "acre's worth" of water in your tank. How much more? The calculation is simple--divide the percentage of active ingredient (in this case, 80) into the total (100).

$$2 \text{ lb. a.i. per acre} \times \frac{100\%}{80\%} = 2 \times 1.25 = 2.5 \text{ lb. of product per acre}$$

So, 2.5 pounds of product is needed for each "acre's worth" of water in the tank to apply 2 pounds of active ingredient per acre.

Sometimes one gets confused and wonders, "Do I divide the 100 by 80 or is it the other way around?" This is where common sense comes in. The label tells you that the commercial material in the bag isn't 100 percent active ingredient--it is only 80 percent. Logic than suggests that you will need some extra material. To get that extra, you have to divide the large number by the small number to get a number bigger than 1.

$$80 \text{ divided into } 100 = \frac{100}{80} = 1.25$$

Next determine the number of acres you can spray with each tankful. Your sprayer has a 400-gallon tank and puts out 20 gallons per acre.

$$\frac{\text{tank capacity (gallons/per tank)}}{\text{spray rate (gallons per acre)}} = \frac{400}{200} = 20 \text{ acres sprayed with each tankful.}$$

Therefore with each tankful you will cover 20 acres and want 2.5 pounds of product per acre, so add 50 pounds (20 acres x 2.5 pounds per acre = 50 pounds of product) of atrazine to each tankful.

Liquid Formulation

A trifluralin recommendation calls for 1 pound of active ingredient per acre. You have purchased Treflan 4E (4 lb./gal. formulation). Your sprayer has a 300-gallon tank and is calibrated at 15 gallons per acre.

First determine the amount of product needed per acre. This is done by dividing the recommended active ingredient per acre by the concentration of the formulation.

$$\frac{1 \text{ lb. a.i. per acre}}{4 \text{ lb. a.i. per gallon}} = 1/4 \text{ gallon per acre}$$

So, 1/4 gallon or 1 quart of product is needed for each "acre's worth" of water in the tank to apply 1 pound of active ingredient per acre.

Next determine the number of acres you can spray with each tankful. Your sprayer has a 300-gallon tank and is calibrated for 15 gallons per acre.

$$\frac{\text{tank capacity (gallons per tank)}}{\text{spray rate (gallons per acre)}} = \frac{300}{15} = 20 \text{ acres sprayed with each tankful.}$$

Therefore with each tankful you will cover 20 acres and want 1/4 gallon (1 quart) of product per acre, so add 20 quarts (20 acres x 1 quart per acre = 20 quarts) of trifluralin to each tankful.

Adjuvants (Spreader-Sticker, Surfactant, etc.)

Often you will encounter a recommendation which says that in addition to the regular chemical you should add a small amount of some adjuvant. This type of recommendation often is given as percent concentration.

If you use adjuvant at a 1/2 percent concentration by volume, how much should you add to a 300-gallon tank?

Solution 1:

1 percent of 100 gallons = 1 gallon (100 x .01 = 1)
1/2 percent of 100 gallons = 1/2 gallon

Therefore you need 1/2 gallon per 100 gallons, or 1 1/2 gallons for 300 gallons (1/2 x 3 = 1 1/2).

Solution 2:

1/2 percent = 0.005
0.005 x 300 gallons = 1.5 gallons needed

PESTICIDE ENFORCEMENT POLICY STATEMENT 7
AERIAL APPLICATION OF A REGISTERED PESTICIDE

David A. Gentry

Following recent court cases concerning aerial application of pesticides, the U.S. Environmental Protection Agency (EPA) has issued the seventh in a series of Pesticide Enforcement Policy Statements (PEPS). The EPA has grouped pesticide labels into the following six categories:
Category I—labels that specifically allow aerial application in accordance with label directions; these labels contain necessary safety precautions and dilutions.
Category II—labels that directly prohibit aerial application under any circumstances.
Category III—labels that have ground application instructions but the dilutions and safety precautions are inconsistent with approved aerial application methods. These pesticides cannot be applied by air unless a special state registration is issued under section 24(c) of FIFRA by the Illinois Department of Agriculture.
Category IV—labels that have no specific ground or aerial instructions but the dilutions and safety precautions are inconsistent with approved aerial application methods. These pesticides cannot be applied by air unless a special state registration is issued under section 24(c) of FIFRA by the Illinois Department of Agriculture.
Category V—labels that have specific ground application instructions but contain dilutions and safety precautions that are consistent with accepted aerial application methods.
Category VI—labels that have no specific method of application but have dilutions and safety precautions that are consistent with accepted aerial application methods.

Categories V and VI are the concern of this PEPS. If a label on a registered pesticide fits into category V or VI it may be applied by air if the following conditions are met: (1) the pesticide is registered on the site or commodity to be treated; (2) the use is recommended in writing by a knowledgeable expert; (3) the recommendation is filed with the state's lead agency (in Illinois it is the Department of Agriculture); (4) the user follows all label restrictions and limitations excluding method of application; and (5) the pesticide is expected to be effective when applied aerially.

The EPA has described what must be included in the recommendation filed by a knowledgeable expert. It must include:

1. Name of pesticide to be used

2. Commodity, crop, or area to be treated

3. Geographic and ecological characteristics of the treated area

4. Pest being controlled

5. Duration of the recommendation (1 year maximum)

6. Dilution rate

7. Mixing and loading instructions
8. Aerial application equipment to be used
9. Calibration of the equipment
10. Aircraft speed
11. Wind velocity
12. Allowable drift
13. Other environmental precautions

A recommendation is acceptable only in the state in which it is filed. In addition, each state can set its own procedures for accepting recommendations. Finally, the knowledgeable expert may be held liable for damages resulting from his recommendation. To qualify as a knowledgeable expert, a series of conditions must be met. People interested in making recommendations under this PEPS should contact the Illinois Department of Agriculture to be sure they qualify.

SUGGESTIONS FOR MINIMIZING BEE, FISH, AND WILDLIFE LOSSES FROM PESTICIDES

G.C. Sanderson, R.C. Hiltibran, E.R. Jaycox

It may be almost impossible to use pesticides without the possibility of endangering some nontarget species, such as fish and wildlife. However, through prudent use, the hazards to fish and wildlife from the use of pesticides can be substantially reduced. Here are some precautions to follow:

1. Apply pesticides according to the instructions given by the manufacturer and the Cooperative Extension Service.

2. If more than one pesticide is available to control a specific pest, use the pesticide least toxic to nontarget organisms. (Usually this information is not readily available to the applicator in the field. Also, frequently there is not much difference between pesticides in toxicity to nontarget organisms.)

3. Avoid drift. (Most applicators are aware of drift problems. However, climatic conditions often change after the application of a pesticide that causes problems, and these cannot always be predicted.)

4. Follow instructions in disposing of pesticide containers.

5. In wildlife and aquatic areas use ground equipment so that pesticides can be confined to specific target areas.

6. Make sure that pesticide-treated seed is not readily available to birds or mammals.

7. Do not apply pesticides to water that are not registered for aquatic use. For application to water, use only those pesticides registered by the federal EPA for aquatic use (Rule 203h, Water Pollution Regulations, as amended).

8. Avoid applying pesticides that are extremely toxic to fishes in the immediate watershed, including ditches and channels that drain into bodies of water.

9. Wash application equipment properly, and do not permit wash water to enter any water area.

SOME CHARACTERISTICS OF ANIMAL POPULATIONS IN ILLINOIS, ONES HELPFUL IN UNDERSTANDING THE WILDLIFE-PESTICIDE PROBLEM

First of all, it should be emphasized that we know little about the overall effects of any pesticide on any population of wild vertebrate animals. Certain general facts have been established, however, A considerable amount of data is available on the acute toxicity of various compounds to a variety of species in captivity. Also, a limited number of studies have been made on the rate of recovery of a population following one or more applications of a pesticide to an area. In populations of wild verbebrates some pesticides may produce great mortality both directly and indirectly through the food chain. It has been shown that persistent chemicals such as the chlorinated hydrocarbons are concentrated from the bottom of the food chain to the top of the food chain so that animals at the top of the food chain often accumulate heavy dosages of the toxin. As a result, whole populations may lose their reproductive capacity. Accumulations of organo-chloro insecticides through the food chain may already have reduced the reproductive capacity of the bald eagle, duck hawk, and other raptor popul tions both in Europe and North America, as well as certain species of fishes and fish eating birds such as loons, cormorants, and pelicans.

While these discussions refer to all wild vertebrates in general, most of the remarks and examples will refer to birds. Because of their migratory and highly mobile nature, a greater number of birds are susceptible to poisoning from a single application of pesticide than are mammals.

Certain ecological principles should be obvious to everyone. The simpler the habitat, the fewer organisms it supports, both in terms of the number of organisms and the variety of organisms. Conversely, the more complex the habitat, the greater the number and variety of organisms. For example, in summer, bare plowed ground usually supports only about 3 to 5 native species of birds with only about 1 bird for every 2 acres. At the other extreme is forest, which supports about 80 to 85 nesting species of birds with about 5 to 8 birds per acre. Of the agricultural habitats in Illinois, corn and soybean fields have the poorest bird populations, essentially the same as plowed bare ground; wheat fields are only slightly better, but oat fields have conspicuously higher bird populations. Grasslands and hayfields are very rich bird habitats with 40 to 70 native species in summer and 3 to 5 birds per acre. The shrub borders and hedges at the edges of cultivated fields have some of the densest populations of birds of any Illinois habitat. Marshlands also have high populations and many species. In Illinois, the prairie-grassland and marsh-dwelling species are the ones in greatest danger of extermination.

Regrettably, the effects of pesticides applied to a wheat field do not stop at the borders of the wheat field because animals, especially birds, from adjacent fields may pass through the poisoned wheat field or even forage at its boundaries. A study made in Illinois in 1964 indicated that in a single breeding season two successive populations of birds were killed in a hayfield from the effects of one application of 1/4 pound of dieldrin on a nearby wheatfield. The hayfield was not sprayed, but the birds there died. A third population of birds that moved into the hayfield within a month of the spray date was unable to produce fertile eggs.

Populations of birds shift greatly from season to season. Between April 15 and June 10, and again between September 1 and November 15, the bird populations in all parts of Illinois reach their greatest heights. Over 200 species are present in the state, and the numbers are many times the normal breeding population. Many of these species are highly insectivorous. After October 1, more and more waterfowl appear in the wetlands of the state. The songbird populations penetrate every habitat, but are most abundant where there is some woody vegetation. Populations of songbird migrants in open field habitats probably reach their peak in late March to mid-May and in October and early November. Fortunately most of the migrants do not spend time in plowed fields, or corn or bean fields, i.e., bare fields. An exception is the golden plover which passes through the state by the thousands in April and May; these birds regularly feed on bare fields and grasslands and concentrate particularly around rain pools.

In Illinois, bird populations reach their lowest levels in the northern third of the state in the winter (Jan. 1 - March 1), but in the southern third of the state winter populations are even higher than the summer populations in practically all habitats.

SOME USEFUL FACTS ABOUT PESTICIDES AND FISH MORTALITY

There are many causes of fish kills in ponds and streams including insecticides, herbicides, liquid fertilizers, barnyard wash, and numerous other factors which affect the supply of oxygen. Specifically some insecticides are much less toxic to fish than others. Proper selection and use of insecticides will reduce potential danger. Extreme care and caution are urged in applying any insecticide near streams and ponds. If toxic agents are applied in a short section of a stream or drainage channel, fish and other animals may be killed as the toxic agent flows downstream. When fish kill occurs, examine all possible causes, including pesticides.

The enclosed table may be of some help to you in answering questions about insecticides and fish kill. We compiled this information from several sources. In using this information, consider the stability of the compound, its tendency to store in fat, method and rate of use, affinity for soil particles, and solubility, as well as exact toxicity.

In the table, LC50 means the amount of pesticide in parts per billion needed to kill 50 percent of the test fish in a 24-hour period in an aquarium. This information indicates those killed immediately after exposure. Low levels of some pesticides may be stored in fat tissues over a period of weeks. Theoretically this stored material could cause fish mortality if the fat was suddenly used under stress and the pesticides were redistributed throughout the fish's system.

LD50 is the number of milligrams (0.001 gram) needed per kilogram (1,000 grams) or 2.2 pounds of body weight to kill 50 percent of selected healthy laboratory test animals, usually white rats. Both oral and dermal toxicities are included in the table.

The LC50 and the rate per acre-foot of water is based on laboratory tests on 2-inch bluegills exposed to that concentration for 24 hours at a water temperature of 75° F. When exposed for 96 hours the concentration required to reach the LC50 was much lower. Toxicity varies greatly with fish species, chemical, and formulation of the chemical. The LC50 for naled (Dibrom) to rainbow trout was 70 ppb and for bluegill, 200 ppb; for trichlorfon (Dylox) it was 28 ppm for trout and 5.6 ppm for bluegill. Thus this table serves only as a guide. Bluegills, popular Illinois fish species, were used as a guide rather than trout.

SOME FACTS ABOUT PESTICIDES AND BEES

Bees are highly important as pollinators of apples, pumpkins, clovers, cantaloupes, watermelons, blueberries, cucumbers, squash, and other crops in Illinois. Some of our common insecticides are highly poisonous to bees of all kinds. They may cause serious losses to social bees, such as honey bees and bumble bees, as well as to the less known solitary bees, such as alkali bees and leaf cutter bees. Efficient management of control programs and of bees can do much to reduce loss of bees through necessary agricultural pest-control operations. Relating spraying operations to knowledge of daily bee activity, insecticide toxicity, plant maturity, and spray drift will reduce bee losses and may mean the difference between a satisfied producer and one faced with a lawsuit.

If informed of intended pesticide applications that could damage bees, a beekeeper may be able to protect his colonies to some extent. Beekeepers are required to register with the Illinois Department of Agriculture, Bureau of Plant and Apiary Protection, 522 South Jefferson, Paris, Illinois 61944. The chief apiary inspector will assist in locating or notifying beekeepers whose bees are endangered. In some cases, local county extension advisers can also be of assistance.

Relative Toxicity of Pesticides to Honey Bees

Pesticides differ greatly in their effect on honey bees. The formulation of the material plays an important role in its toxicity to bees. In general, sprays are safer than dusts, and emulsifiable concentrates are less toxic than wettable powders. Granular materials usually are not hazardous to bees. Microencapsulated formulations of highly toxic materials are extremely hazardous to bees. Penncap-M should not be used on crops visited by bees, or in locations where it may contaminate other blooming crops or weeds.

Fungicides, acaricides (miticides), herbicides, and blossom thinners are relatively nontoxic. These materials and the insecticides can be placed in three groups in relation to their effects on bees--those highly toxic, those moderately toxic, and those relatively nontoxic.

Insecticides Highly Toxic to Bees

This group includes materials that kill bees on contact during application and for one or more days after treatment. Bees should be moved from the area if highly toxic materials are used on plants the bees are visiting. This group includes:

aldrin	dicapthon	methomyl (Lannate)
aldicarb (Temik)	dichlorvos (Vapona) (DDVP)[a]	methyl parathion
arsenicals	dieldrin	mevinphos (Phosdrin)[a]
azinphosethyl (Ethyl Guthion)	dimethoate (Cygon)	microencapsulated methyl parathion
azinphosmethyl (Guthion)	dinitrobutylphenol (DNOSBP)	Mobam
Azodrin	EPN	naled (Dibrom)[a]
Banol	fensulfothion (Dasanit)	parathion
BHC	fenthion (Baytex)	phosmet (Imidan)
Bidrin	Gardona	phosphamidon (Dimecron)
Bomyl	heptachlor	propoxur (Baygon)
carbaryl (Sevin)	lindane	Pyramat
carbofuran (Furadan)	malathion	Telodrin
chlordane	malathion ULV	Zectran
chlorpyrifos (Dursban)	Matacil	Zinophos
crotoxyphos (Ciodrin)	Metacide	
diazinon		

[a]Short residual activity. Can usually be applied safely when bees are not in flight. Do not apply over hives.

Insecticides Moderately Toxic

These materials can be used with limited damage to bees if not applied over bees in the field or at the hives. Correct dosage, timing, and method of application are essential. This group includes:

biothion (Abate)	Galecron (Fundal)
carbophenothion (Trithion)	methyl demeton (Meta Systox)

Insecticides Moderately Toxic (cont.)

- Carzol
- coumaphos (Co-Ral)
- DDT
- demeton (Systox)
- Dimetilan
- disulfotan (Di-Syston)
- endosulfan (Thiodan)
- endothion
- endrin
- mirex
- oxydemetonmethyl (Meta Systox R)
- Perthane
- phorate (Thimet)
- phosalone (Zolone)
- Pyramat
- ronnel
- tartar emetic

Insecticides Relatively Nontoxic

Materials in this group can be used around bees with few precautions and a minimum of injury to bees. This group includes:

Relatively Nontoxic Insecticides

- Acarol
- allethrin
- Aramite
- *Bacillus thuringiensis*
- binapacryl (Morocide)
- Bordeaux mixture
- chlorbenside (Mitox)
- chlorobenzilate
- chloropropylate
- dicofol (Kelthane)
- Dilan
- Dimite (DMC)
- dioxathion (Delnav)
- ethion (Nialate)
- fenson (Murvesco)
- Kepone
- Lethane
- Lovozal
- methoxychlor
- Morestan
- nicotine
- Omite
- oil sprays (superior type)
- ovex
- Pentac
- Plictran
- Pyrethrum
- rotenone
- sabddilla
- Strobane
- Sulphenone
- TDE (Rhothane)
- tetradifon (Tedion)
- toxaphene
- trichlorfon (Dylox, Dipterex)

*Relatively Nontoxic Fungicides**

- bordeaux mixture
- captan
- copper oxychloride sulfate
- copper 8-quinolinolate
- copper sulfate
- copper oxide
- Dexon
- dichlone (Phygon)
- dinocap (Karathane)
- dodine (Cyprex)
- Dyrene
- ferbam (Fermate)
- folcid (Difolatan)
- folpet (Phaltan)
- glyodin (Glyoxide)
- maneb (Manzate)
- Mylone
- nabam (Parzate)
- Polyram
- sulfur
- thiram (Arasan)
- zineb (Parzate)
- ziram (Zerlate)

*Most fungicides, herbicides, and defoliants are relatively nontoxic.

*Relatively Nontoxic Herbicides**

amitrole	MCPA
CDAA (Randox)	monuron
CDEC (Vegedex)	NPA
dalapon	paraquat
dicamba (Banvel-D)	Planavin
diquat	sesone
diuron (Karmaex)	simazine
EPTC (Eptam)	2,3,6-TBA (Trysben)
EXD (Herbisan)	2,4-D
IPC	2,4,5-T

*Relatively Nontoxic Defoliants**

DEF	PREP
merphos (Folex)	

SOME ADDITIONAL POINTS TO REMEMBER

1. Prevention of bee losses is the joint responsibility of the spray operator, the farmer, and the beekeeper. Before spraying is done, the beekeeper should be notified in ample time to allow him to arrange to protect or move his colonies.

2. Sprays generally are less hazardous to bees than are dusts.

3. Late evening and early morning spray treatments (after 9 p.m. DST and before dawn, 3 a.m.) will generally reduce bee deaths. However, applications to corn are safer to bees when made between noon and midnight, *not* early in the morning.

4. Aircraft applications of technical/low volume malathion are HIGHLY poisonous to bees and should be used chiefly on rangelands for grasshopper control.

5. Ground sprayer treatments usually are less severe on bees than are aircraft applications.

6. Spraying or dusting while bees are active in the fields will increase bee kills.

7. Treatment over hives when bees are clustered outside the hive during hot weather increases bee deaths.

8. Drift to neighboring fields in blossom, or to adjacent blossoming weeds and wild flowers, may result in substantial bee poisoning.

9. Bees located in or very near fields before pesticide treatment may sustain serious death losses. Bees moved into fields and orchards after spraying is completed may suffer little loss.

10. For safest applications around bees, use the recommended amount of the least toxic pesticide to bees that can be expected to accomplish effective control of the pest concerned.

11. Bees fly most actively at temperatures above 55° F. Spraying when temperatures stay below 55° will do little harm to bees.

12. Insecticides cause heavy bee losses when applied to orchards when trees are not in bloom but when there is attractive clover beneath them, and to alfalfa when weeds, such as yellow rocket and mustard, are in bloom.

Insecticides, Their Common Agricultural Rates, Extent of Use, LD50 to White Rats and Other Animals, 24-Hour LC50 to Bluegills, and the Calculated 24-Hour LC50 in Pounds of Toxicant per Water Acre 3 Feet Deep

Insecticide	White rats Approximate LD50, mg./kg. Oral	Dermal	Common agr. rate, (lb./A.)	Use in Illinois	Birds[a] LD50 mg/kg	Fish LC50, ppb	Lb. toxicant per ft.-acre for blue-gill LC50	Comments apply only to fish kill
toxaphene[b]	85	925	1.5	Moderate	31	7	.02	Extremely toxic to fish. Do not use in the vicinity of streams or ponds.
DDT[b]	115	2,510	...	None	595	7[c]	.02	
azinphosmethyl (Guithion)[d]	12	220	.5	Moderate	75	8?	.02+	
aldrin[b]	49	98	1.0 to 1.5	Heavy[e]	6	10	.03	
phorate (Thimet)[d]	1	3	1.0	Heavy	<1	10	.03	
rotenone	75	940+	...	None	>1,414	24	.06	
methoxychlor[b]	5,000	6,000+	1.5	Light	>2,000	31	.08	
heptachlor[b]	131	230	1.0 to 1.5	Moderate[e]	>2,000	35	.09	
diazinon[d]	92	680	1.0	Moderate	4	54	.15	Highly toxic to fish. Use great caution if applied in the immediate vicinity of streams and ponds.
parathion	12	14	.25 to .5	Light	2	56	.15	
lindane[b]	89	950	...	None	900	61	.16	
malathion[d]	1,200	4,000+	1.0	Moderate	167	120	.32	Moderately toxic to fish. Use cautiously around streams and ponds. Avoid direct application of agricultural sprays to water insofar as fish are concerned.
demeton (Systox)[d]	5	11	...	None	7	195	.53	
naled (Dibrom)[d]	250	800	.75	Light	52	220	.59	
carbofuran (Furadan)	5	885	.75-1.0	Heavy	<1	240[f]	.60	
carbaryl (Sevin)[g]	675	4,000+	1.0 to 2.0	Heavy	265	3,400	9.2	Least toxic to fish. Reasonably safe to use around ponds or streams insofar as fish are concerned.
trichlorfon (Dylox)	595	2,000+	1.0	Light	37	5,600	15.1	
methyl parathion[d]	19	67	.25-.5	Light	8	8,500	23.0	
dimethoate (Cygon)[d]	215	505	.5	Light	9	28,000	75.6	

[a]Test bird: Mallard duck, ring-necked pheasant, bobwhite, or California quail. Toxicant administered as a single oral dose. Data from Denver Wildlife Research Center, Bureau of Sport Fisheries and Wildlife.

[b]Chlorinated hydrocarbons, aldrin (as dieldrin), DDT, dieldrin, and heptachlor (heptachlor epoxide) are stored in fat and persist as residues. Methoxychlor is less readily stored, and its toxicity is lower than many others. Toxaphene does not tend to store and is rapidly excreted.

[c]Lower than some studies show.

[d]Organic phosphates are usually not readily stored and break down in water. Some are highly toxic to warm-blooded animals.

[e]Used as soil treatments; adheres readily to soil particles.

[f]Four-day exposure for LC50.

[g]This carbamate is more residual than many phosphates but is relatively nontoxic to fish and wildlife.

POISON TREATMENT CENTERS IN ILLINOIS

The poison treatment centers listed below are designated hospitals that are prepared to handle poisoning accidents. The regional poison resource centers can provide licensed physicians with information about the treatment of poisoning cases. These lists were compiled in October, 1977.

ALTON
St. Joseph's Hospital
915 East 5th Street
(618) 463-5151

BELLEVILLE
Memorial Hospital
4501 North Park Drive
(618) 233-1925--Ext. 250

St. Elizabeth's Hospital
211 South 3rd Street
(618) 234-2120

BLOOMINGTON-NORMAL
Brokaw Hospital
Virginia at Franklin
Normal
(309) 829-7685--Ext. 274

St. Joseph's Hospital
2200 East Washington Street
Bloomington
(309) 662-3311--Ext. 356

CANTON
Graham Hospital Association
210 West Walnut Street
(309) 647-5240--Ext. 240

CARBONDALE
Memorial Hospital of Carbondale
404 West Main Street
(618) 549-0721--Ext. 341

CENTRALIA
St. Mary's Hospital
400 North Pleasant Avenue
(618) 532-6731--Ext. 716

CHAMPAIGN-URBANA
Burnham City Hospital
407 South Fourth Street
Champaign
(217) 337-2533

Carle Foundation Hospital
611 West Park Street
Urbana
(217) 337-3311

Mercy Hospital
1400 West Park Street
Urbana
(217) 337-2131

DANVILLE
Lakeview Medical Center
812 North Logan Avenue
(217) 443-5221

St. Elizabeth Hospital
600 Sager Avenue
(217) 442-6300--Ext. 647, 674, 736

DECATUR
Decatur Memorial Hospital
2300 North Edward Street
(217) 877-8121--Ext. 676

St. Mary's Hospital
1800 East Lake Shore Drive
(217) 429-2966--Ext. 731, 732, 733, 742

DIXON
Katherine Shaw Bethea Hospital
403 East First Street
(815) 288-5531

GALESBURG
Galesburg Cottage Hospital
695 North Kellogg Street
(309) 343-8131--Ext. 336, 356, 386

St. Mary's Hospital
3333 North Seminary Street
(309) 343-3161--Ext. 255, 256

JERSEYVILLE
Jersey Community Hospital
400 Maple Summit Road
(618) 498-6402

JOLIET
Silver Cross Hospital
1200 Maple Street
(815) 729-7563, 729-7565

St. Joseph Hospital
333 North Madison Street
(815) 725-7133--Ext. 679, 680

KANKAKEE
Riverside Hospital
350 North Wall Street
(815) 933-1671--Ext. 606

St. Mary's Hospital
500 West Court Street
(815) 939-4111-Ext. 735

KEWANEE
Kewanee Public Hospital Association
719 Elliott Street
(309) 853-3361--Ext. 219

LINCOLN
Abraham Lincoln Memorial Hospital
315 Eighth Street
(217) 732-2161--Ext. 346

MOLINE
Lutheran Hospital
501 10th Avenue
(309) 764-5661

Moline Public Hospital
635 10th Avenue
(309) 762-3651--Ext. 233

MT. VERNON
Good Samaritan Hospital
605 North 12th Street
(618) 242-4600--Ext. 521

QUINCY
Blessing Hospital
1005 Broadway
(217) 223-5811--Ext. 255

St. Mary's Hospital
1415 Vermont Street
(217) 223-1200--Ext. 260

ROCKFORD
Rockford Memorial Hospital
2400 North Rockton Avenue
(815) 968-6861--Ext. 441

St. Anthony Hospital
5666 East State Street
(815) 226-2041

Swedish American Hospital
1400 Charles Street
(815) 968-6898--Ext. 534

ROCK ISLAND
Rock Island Franciscan Hospital
2701 17th Street
(309) 793-1000--Ext. 2106

SILVIS
Illini Hospital
801 13th Avenue
(309) 792-9363

SPRINGFIELD
Memorial Medical Center
First and Miller Streets
(217) 528-2041--Ext. 460

Springfield Community Hospital
5230 South 6th-Frontage Road
(217) 529-7151

STERLING
Community General Hospital
1601 First Avenue
(815) 625-0400

STREATOR
St. Mary's Hospital
111 East Spring Street
(815) 673-2311--Ext. 221

WOOD RIVER
Wood River Township Hospital
Edwardsville Road
(618) 254-3821

REGIONAL POISON RESOURCE CENTERS IN ILLINOIS

PEORIA
St. Francis Hospital
530 N.E. Glen Oak Avenue
Peoria, Illinois 61637
(309) 672-2000

SPRINGFIELD
St. John's Hospital
800 E. Carpenter
Springfield, Illinois 62702
(217) 544-6464


BEFORE USING ANY
PESTICIDE
STOP
READ THE LABEL